

**FINAL**  
**DATA REPORT No. 2**

**TIER 2 PERMITTING MONITORING:  
EXPENDABLE CURRENT PROFILER (XCP)  
MEASUREMENTS  
AT THE 106-MILE SITE**

**EPA Contract No. 68-C8-0105  
Work Assignment 3-7**

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## 1.0 INTRODUCTION

This data report presents a summary of results for expendable current profiler (XCP) measurements made at the 106-Mile Deepwater Municipal Sludge Dump Site (106-Mile Site) during the period from December 1990 through June 1991. A previous data report (Battelle, 1991) presents a summary of XCP measurement results for the period March through November 1990. Ocean disposal of sewage sludge has been conducted at the 106-Mile Site since 1986. Monitoring activities of disposal operations, sludge fate, and resultant effects have been performed under the Environmental Protection Agency (EPA) Monitoring Plan for the 106-Mile Site (Battelle, 1988a,b). In 1988, the Congress of the United States passed the Ocean Dumping Ban Act (ODBA). Under the ODBA, EPA, the National Oceanic and Atmospheric Administration (NOAA), and the United States Coast Guard (USCG) have developed a joint Monitoring, Research, and Surveillance Plan (joint Monitoring Plan) for the 106-Mile Site (EPA, 1990). Under the joint Monitoring Plan, EPA is responsible for studies designed to evaluate the farfield fate (Tier III) of sewage sludge disposed at the 106-Mile Site. EPA also utilizes data produced by other agencies for some of the data-interpretation tasks.

The 106-Mile Site farfield-fate studies focus on determining the transport and fate of the sewage sludge, using a variety of physical oceanographic techniques. These include measuring vertical current shears with XCPs, taking vertical temperature profiles with expendable bathythermographs (XBT), determining currents with moored current-meter arrays (Eulerian measurements), using satellite-tracked drifting buoys to determine water-mass movement (Lagrangian measurements), and measuring sea-surface temperatures (SST) with imagery from satellite-based sensors. Under the joint Monitoring Plan, each agency as well as the permittees using the 106-Mile Site for sludge disposal are responsible for acquiring data via these various oceanographic techniques. This data report summarizes the results of XCP measurements made at the 106-Mile Site during the period from December 1990 through June 1991. The final XCP deployment under the presently defined study program for the 106-Mile Site occurred on June 1, 1991. Comprehensive analyses and syntheses of results from the various measurement programs will be addressed in reports prepared under separate work assignments.

The XCP measurements reported here have been performed under Work Assignments 1-07 and 2-07 to the EPA Office of Marine and Estuarine Protection (in April 1991, the Office of Marine and Estuarine Protection became part of the new EPA Office of Wetlands, Oceans, and Watersheds). These work assignments also include XBT measurements made at the 106-Mile Site; the results for the XBT measurements are summarized in separate reports.

## 2.0 XCP DEPLOYMENT SUMMARY

Under the permits issued for sludge disposal at the 106-Mile Site, the sewerage authorities holding the permits (permittees) were required to deploy an XCP at the Site on an approximate weekly basis. The permittees were required to complete a deployment log (Figure 1) for each XCP deployment and to send the resultant data tape and log sheet to Battelle for processing, archiving, and analysis.

The XCP system utilized by the permittees is manufactured by Sippican, Inc. (Marion, Massachusetts). The XCP system comprises an XCP probe and surface float with radio transmitter, launched from the sludge barge, and a receiver/recorder unit that was aboard the barge tow vessel. An antenna aboard the tow vessel was connected via coaxial cable to the receiver/recorder unit. Shortly after entering the water during launch (approximately 40 s), the XCP probe separates from the free-floating surface buoy and descends at a known rate through the water column.

Each XCP probe contains sensors for measuring water temperature and orthogonal electrical potentials proportional to the current-velocity changes with depth (current shears). Magnetic sensors are also incorporated into the probes, so that the orientation of the relative current velocity can be determined relative to the earth's magnetic field. The sensor measurements are telemetered to the surface buoy via thin, coated wires (dual magnet wire), which are dereeled from spools located in both the probe and the surface buoy. This dual-spool arrangement permits the probe to descend smoothly, with the rate of descent being governed by the probe's predetermined terminal velocity through the water column. The depth of the probe at any instant is determined via a quadratic equation dependent on the elapsed time of

XCP DEPLOYMENT SHEET

.....TRIP INFORMATION.....

Name of Transport Company: A & S Transportation Co.

Name of Towing Vessel: \_\_\_\_\_

Name of Barge: \_\_\_\_\_

XCP Operator Signature: \_\_\_\_\_

Port of Departure: \_\_\_\_\_

Time: \_\_\_\_\_ Date: \_\_\_\_\_

.....XCP INFORMATION.....

XCP Serial Number: \_\_\_\_\_

Predeployment Checkout: Time: \_\_\_\_\_ Date: \_\_\_\_\_

Signal to Receiver: Pass \_\_\_\_\_ Fail \_\_\_\_\_  
(RF quieting)

.....XCP LAUNCH INFORMATION.....

Position of Launch:

\_\_\_\_\_ N LAT LORAN TD's \_\_\_\_\_  
\_\_\_\_\_ W LONG \_\_\_\_\_

Time of Launch: \_\_\_\_\_ Date of Launch: \_\_\_\_\_

Weather:

True Wind Direction: \_\_\_\_\_ Deg True Wind Speed: \_\_\_\_\_ Kts

Wave Height: \_\_\_\_\_ Ft

.....XCP DEMOBILIZATION.....

XCP Operations Coordinator (signature) \_\_\_\_\_

Figure 1. XCP Deployment Sheet

descent. Sensor data were telemetered from the surface buoy via a radio frequency (RF) signal to the receiving antenna located on the tow vessel, which eliminates the need for a physical wire link between the probe/buoy and the tow vessel. The tow vessel carried an antenna, radio receiver, and a tape recorder unit used to acquire a cassette tape copy of the sensor data from the XCP probe. The data tape and deployment log sheet were then mailed to Battelle after the tow vessel had returned to port.

The training of permittee technicians in the installation and operation of the XCP system was performed by Clearwater Consultants (Newton, Massachusetts).

A single XCP shipboard system (antenna/receiver/recorder) was provided for the XCP program, necessitating that the system be transportable since different tow vessels were utilized by the permittees. Four of the tow vessels used by the permittees were outfitted with permanent Yagi antennas in late spring 1990, and three other vessels were outfitted with permanent Yagi antennas in July 1990. Tow vessels without permanent Yagi antennas used a portable whip antenna that always accompanied the shipboard receiver/recorder unit. The XCP probes are self-contained units, and were carried aboard the sludge barges, as needed, for launching at the 106-Mile site.

Note that in April 1991 it was decided by EPA Region II to end the program of XCP deployments from the permittee barges, and to begin weekly XCP deployments via aircraft overflights of the 106-Mile Site. XCPs were launched from the overflying aircraft utilizing a small drogue parachute attached to the XCP probe/surface buoy package. Upon entering the water, this small parachute detached from the deployment package, and the XCP probe began its normal detachment process from the surface buoy leading to the descent of the probe through the water column to obtain the XCP profile. After launching the XCP package, the deployment aircraft then circled the launch point to receive and record the RF signal from the XCP surface buoy. This airlaunch XCP program was initiated in an attempt to eliminate intermittent noise spiking problems that were contaminating some of the XCP data profiles (discussed in Section 4.0). The deployment aircraft was configured with an antenna and an XCP receiver/recorder unit. The aircraft-launched XCP program continued until June 1, 1991, when the XCP deployment program was formally ended.

The XCP deployments performed during the period December 1990 through June 1991 are summarized in Table 1. XCP deployments which were accomplished via aircraft overflights are suffixed by the letter a in the XCP No.

### **3.0 XCP DATA PROCESSING**

Upon receipt at Battelle's Duxbury, Massachusetts, facility, the XCP data tapes and accompanying deployment log sheet were logged in by Battelle personnel prior to processing. A cassette-tape player and Sippican model MK 10 digital interface were utilized with a PC to translate and process the XCP data. Software provided by Sippican was installed on the PC for processing the data. Following digitization and transfer of the data to the PC, a header record was created by using information provided on the accompanying deployment log sheet, such as the date, time, and position of deployment, the tow-vessel name, cruise number, XCP ID number, and additional information related to the operation of the XCP probe. The header record was merged with the digital XCP data file and was retained with the data file through all subsequent processing and data archiving.

Processing software was then utilized to convert the raw digital XCP data into nine variables: depth, temperature, east and north components of velocity, and five technical parameters relating to probe performance. In addition, the header record was expanded to include the parameters used during the postprocessing function to create the processed data file. The expanded header record and processed data variables were then used as the archived data file. Figure 2 shows the XCP data-processing sequence; Figure 3 is the checklist used by Battelle for each step in the processing of the XCP data.

### **4.0 PROBLEMS ENCOUNTERED AND CORRECTIVE ACTIONS**

Several problems were experienced during the XCP deployment program that have affected data return and data quality. This Section discusses the problems and corrective actions taken to obtain good-quality XCP data consistently.

Table 1. XCP Survey Deployments

XCP #	Date Deployed	Longitude (deg W)	Latitude (deg N)	Serial Number
30	12/01/90	72°01.85′	38°59.13′	89061054
31	12/07/90	72°02.00′	38°59.80′	89061019
32	01/15/91	72°02.90′	39°00.00′	90021007
33	01/19/91	72°01.90′	38°57.50′	89101067
34	01/26/91	72°01.84′	38°59.93′	89101056
35	02/02/91	72°02.97′	38°59.79′	89101039
36	02/07/91	72°02.00′	39°00.00′	89091123
37	02/18/91	72°02.21′	38°59.45′	89091082
38	03/13/91	72°01.94′	39°00.00′	90121067
39a	04/12/91	72°03.90′	39°00.00′	90121118
40a	04/19/91	72°03.90′	39°00.00′	90111020
41a	04/25/91	72°04.00′	39°00.00′	90121115
42a	05/02/91	72°03.80′	38°59.90′	90121112
43a	05/07/91	72°03.90′	39°00.00′	90121113
44a	05/13/91	72°04.10′	39°00.10′	90121110
45a	05/19/91	72°04.00′	39°00.00′	90121061 <sup>a</sup>
46a	05/20/91	72°04.10′	39°00.00′	90121066
47a	06/01/91	72°03.90′	39°00.00′	91051026

Note: XCPs suffixed by the letter a designate air-launched probes.

<sup>a</sup>Probe failure on XCP #45a.

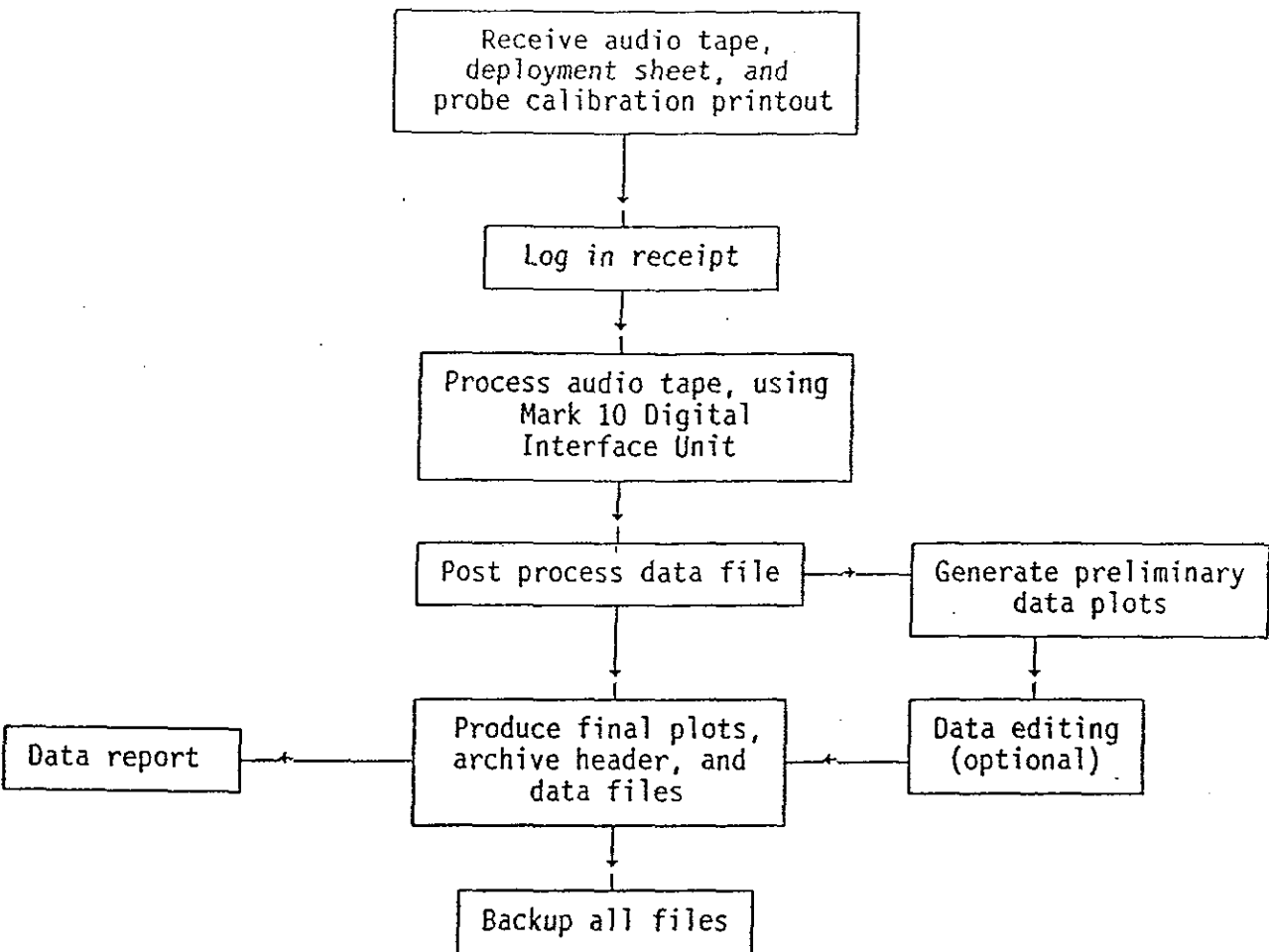


Figure 2. Processing Sequence for XCP Data Reduction

EPA/OMEP WA-07 - XCP PROGRAM  
BATTELLE DATA PROCESSING CHECKLIST

Name: \_\_\_\_\_ Date/Time: \_\_\_\_\_

1. Log in Tape, calibration sheet and deployment sheet, assign cruise number.

- \_\_\_ (x) Package submitted within one week of deployment. If not, days late? \_\_\_\_
- \_\_\_ (x) Cassette is write protected and labeled correctly. If not, do it
- \_\_\_ (x) Launch is on 5 to 9 day interval. If not, days since last deployment? \_\_\_\_
- \_\_\_ (x) Launch within 1 nm from 39-00 N 72-00 W or 39-00 N 72-02 W. If not, how far? \_\_\_\_

Attach Calibration Sheet Here

2. Process the Data

- a. Edit file \MK10\XCAL.TXT. Add XCP serial number and calibration coefficients Gcca, Gcora, Gefa, Gevfa, and Gcvfa.
- b. Start PC, type "MK10" to invoke batch file which runs processing program.
- c. Check that red LED is illuminated, indicating machine speed of 8 MHz
- d. Start Mark 10 unit, hear six tones indicating successful self test  
====> If six tones not heard, pull top two boards, clean finger contacts
- e. Find tape beginning, set volume to 4.0, check equalizer if applicable
- f. Enter Latitude, Longitude, cruise number, and Ship (Towing Vessel)
- g. Press "F1" for probe window, enter serial number of probe.
- h. Enter filename "XCPxx#" where xx is the cruise number, and # is the number of the read you are now doing (start with 0).
- i. Press "F4" to calculate magnetic field values.
- j. Press "ESC" to start program, start tape rolling and start stopwatch.
- k. Monitor signal, adjust volume if necessary.
- l. When signal stops, turn off tape player, write total time here ====> \_\_\_\_\_
- m. If there are any spikes in the data, go to step h above and repeat.
- n. Run "MK10PP" program to post process
- o. Type "Alt-O" to open a file, open the one with the best data using extension ".hdr"
- p. Press "F4" to process data. Exit to DOS.
- q. Move files with extensions ".phr" and ".pro" to xcp data directory and backup disk.

3. Perform Analysis with MATLAB

- a. Run 386 MATLAB
- b. Load the file with extension ".pro"
- c. Run "brkup.m", answer questions to prompts
- d. Run "plotit.m", save graph to meta file
- e. Run "plottech.m", graphs will be saved to plottech.met

**Figure 3. XCP Data Processing Checklist**

Table 2 summarizes the XCP data quality for the December 1990 through June 1991 reporting period.

As discussed in the previous XCP data report summarizing XCP measurement results for the period March through November 1990 (Battelle 1991), the XCP data tapes showed intermittent contamination resulting in spikes in the profiles when the data tapes were processed. This noise problem was not readily discernible on the audio monitor, and had no obvious dependence on the probe depth or distance to the surface buoy transmitter. Fortunately, even with the spiking present, the current velocity and temperature profiles were largely recoverable with only minor perturbations left in the edited XCP profiles. An auxiliary data parameter produced during the processing of the profile data is related to potential velocity errors (termed *Velerr*, a standard deviation) and was utilized consistently in the editing of the data profiles. When *Velerr* exceeded a preselected value (1 cm/s), the profile values at that depth level were deleted from the edited data set. Raw, unedited profiles as well as edited profiles are maintained in the data archives at Battelle.

Note that for XCP No. 32, all of the profile data points had *Velerr* values exceeding 1 cm/s. A usable, but noisy, profile of current velocity was obtained by setting the *Velerr* editing value to 10 cm/s rather than the usual 1-cm/s value (see Figure A-3 in the Appendix). Also note that XCP No. 47a did not have enough valid data points to provide a usable profile, and thus is not in the data profiles presented in the Appendix.

Profiles having more than 80% good data points (i.e., fewer than 20% spikes that were removed via editing) are denoted as good under the Data Quality column in Table 2. Profiles having between 50% and 80% good data points (i.e., with between 20% and 50% spikes) are designated as fair in Table 2. Profiles having fewer than 50% good data points (i.e., more than 50% spikes) are designated as poor in Table 2. The percentage of good data points for each profile is indicated parenthetically in Table 2 following the Data Quality designation.

In addition to the spiking noise contamination described above, several data tapes received at Battelle had no retrievable data present on their tapes. These are denoted in Table 2 as no data in the Data Quality column (XCPs No. 35 and No. 38). Finally, XCP No. 45a is denoted

Table 2. XCP Data Summary

XCP #	Date Received	Date Deployed	Serial Number	Data Quality
30	12/17/90	12/01/90	89061054	poor (25%)
31	12/26/90	12/07/90	89061019	poor (45%)
32	01/25/91	01/15/91	90021007	poor (0%)
33	01/28/91	01/19/91	89101067	fair (70%)
34	02/01/91	01/26/91	89101056	good (94%)
35	02/11/91	02/02/91	89101039	no data <sup>b</sup>
36	02/20/91	02/07/91	89091123	poor (23%)
37	03/06/91	02/18/91	89091082	poor (23%)
38	03/21/91	03/13/91	90121067	no data <sup>b</sup>
39a	05/01/91	04/12/91	90121118	fair (63%)
40a	05/01/91	04/19/91	90111020	fair (69%)
41a	05/06/91	04/25/91	90121115	good (95%)
42a	05/05/91	05/02/91	90121112	good (96%) <sup>c</sup>
43a	05/20/91	05/07/91	90121113	good (97%)
44a	05/20/91	05/13/91	90121110	good (98%)
45a	06/10/91	05/19/91	90121061	probe failure
46a	06/10/91	05/20/91	90121066	good (90%)
47a	06/10/91	06/01/91	91051026	poor (1%) <sup>d</sup>

Note: XCPs suffixed by the letter a designate air-launched probes.

<sup>a</sup>XCP No. 32 was processed using Velerr value of 10 cm/s (see text).

<sup>b</sup>XCP No. 35 and XCP No. 38 tapes contained no data.

<sup>c</sup>XCP No. 42a profile has no data below 1150 m.

<sup>d</sup>XCP No. 47a did not contain sufficient valid data points to provide usable profiles.

in Table 2 as a probe failure. This is a result of the XCP probe failing to separate from its surface buoy after being launched.

Another problem was encountered in the processing of the XCP data tapes relating to the use of XCP probe calibration coefficients supplied by the manufacturer with each probe. Technical review of XCP profiles obtained during the project revealed an apparent offset to be present in the north–south component velocity profiles, when profiles generated at Battelle (using the individual probe calibration coefficients provided by the manufacturer) were compared to profiles generated by Dr. Thomas Sanford (Applied Physics Laboratory, University of Washington), inventor of the XCP. The profiles from Dr. Sanford were generated from copies of the original raw data tapes processed at Battelle, with the difference between the processing procedures residing in the values of the probe calibration coefficients utilized during processing. Dr. Sanford utilizes nominal probe calibration coefficients based on the specific electronic circuitry design for the XCP probe, and these are the same for each probe manufactured to the same circuitry specifications. The manufacturer, however, has followed a practice of individually calibrating each probe during manufacturing production, and provides a list of calibration coefficients with each individual probe to be used during data processing.

The comparisons between north–south component velocity profiles generated via use of the nominal calibration coefficients from Dr. Sanford and those generated via use of the manufacturer-supplied coefficients showed the manufacturer-derived profiles to have an average bias of +18 cm/s (i.e., more northerly flowing). It was Battelle's technical opinion that the more southerly directed profiles derived with Dr. Sanford's nominal coefficients seemed to correspond better to the overall flow characteristics at the 106-Mile Site observed via other independent methods. Following a meeting in February 1991 with the manufacturer, an engineering review of the procedures used for determination of XCP probe calibration coefficients during production essentially concluded that the procedures presently utilized by the manufacturer are not valid to the level of precision required in the data processing, and the use of the nominal coefficients from Dr. Sanford is recommended.

The nominal coefficients were then utilized to consistently reprocess all of the collected XCP data tapes for the 106-Mile Site project, including the data presented in this report. The nominal calibration coefficients utilized for the XCP processing are listed below.

Descriptions of the meaning of each coefficient may be found in Sanford *et al.* (1982).

<u>XCP Calibration Coefficient</u>	<u>Nominal Value</u>
Gcca	1813
Gcora	918
Gefa	25260
Gevfa	495
Gcvfa	500

Finally, it should be noted that the XCP probe measurements may be contaminated by electromagnetic effects when in the vicinity of the deployment vessel, because of galvanic-type electrical currents (corrosion currents) or currents arising from impressed cathodic potentials for vessel corrosion protection. The effects of this vessel-induced contamination on XCP measurements are discussed in Sanford *et al.* (1982), and typically can result in large, spurious current speeds (and velocity components) being indicated by the XCP in the near-surface zone when the probe is closest to the deployment vessel. (Note that this is not a problem of concern with the aircraft-launched XCP Nos. 39a through 47a.)

The XCPs for the 106-Mile Site XCP program utilize an approximate 40-s delay from time of water-surface entry to the time of probe release for profiling descent in order to allow the deployment vessel to move away from the probe prior to commencement of its profiling descent and, thus, mitigate the vessel-induced contamination. Since several vessel lengths of separation between probe and deployment vessel are recommended to mitigate these effects, the 40-s delay is usually effective for this purpose. However, approximately 33% (two out of six) of the barge-launched XCP profiles presented in the Appendix exhibit high current speeds in the near-surface zone, which may be attributable to the vessel-induced contamination effects. Given that the barges are towed at approximately 5 kn during dumping operations (and XCP launches), the 40-s delay in the release of the probe equates to slightly more than

one barge length of separation. This will vary, however, since the speed of tow vessel and barge is variable during the dumping. Also, the combined tow vessel/tow cable/barge system may result in a larger-scale contamination field. Thus, the occurrence of high velocities in the near-surface zone must be regarded as *possible* vessel-induced contamination. High current speeds in the near-surface zone *can* occur, such as during eddy passages through the 106-Mile Site, so the high speeds indicated in the barge-launched XCP profiles cannot be automatically rejected as spurious, but should be carefully reviewed in the context of the governing oceanographic regime at the time of measurement. This will be done during data synthesis and interpretation to be performed under separate work assignments. For the present XCP data report, these potentially spurious, high-speed, near-surface currents are indicated below for the individual barge-launched XCP profiles presented in the Appendix.

<u>XCP No.</u>	<u>Possible Spurious Near-Surface Profile Data</u>
31	Above 85 m
32	Above 120 m

## 5.0 XCP DATA PRODUCTS

XCP data-profile displays are presented in the Appendix to this data report for each XCP that provided recoverable data. Analysis and synthesis of these data, combined with other data acquired at the 106-Mile Site, will be performed and reported under separate work assignments. For each XCP presented in the Appendix, five profile plots are provided. Figures denoted with an (a) show north and east velocity-component profiles (with respect to true north and east coordinates at the 106-Mile Site). Figures denoted with a (b) give speed and direction (with respect to true north coordinates) profiles. The figures denoted with a (c) provide the temperature-profile data obtained with the XCP (in degrees Celsius). The data presented are from the edited data archives.

Note that the velocity-component and speed/direction profiles represent relative velocities; any current component(s) found uniform over the entire depth range (i.e., does not change as a function of the depth) will not be measured by the XCP technique. Thus, the velocity profiles obtained and presented are *relative* velocities, not absolute with respect to the

underlying seabed, and this is why the XCP profiles are sometimes referred to as *velocity shear* profiles. To obtain absolute velocity profiles, the uniform, depth-independent velocity must be obtained via an independent method, and then added as a vector to the XCP relative velocity profiles to obtain absolute velocity profiles. Also note that the velocity profiles presented in the Appendix utilize standard oceanographic convention, such that the directions given indicate the direction *toward* which the current is flowing. North-component velocities are positive when flowing toward north, and the orthogonal east-component velocities are positive when flowing toward east.

## 6.0 REFERENCES

- Battelle. 1991. Tier 2 Permittee Monitoring: Expendable Current Profiler (XCP) Measurements at the 106-Mile Site. Draft data report submitted to the U.S. Environmental Protection Agency under Contract No. 68-C8-0105, dated May 6, 1991.
- EPA. 1990. Monitoring, Research, and Surveillance Plan for the 106-Mile Deepwater Municipal Sludge Dump Site and Environs. Environmental Protection Agency Office of Water. EPA 503/4-91/001.
- Sanford, T.B., R.G. Drever, J.H. Dunlap, and E.A. D'Asaro. 1982. Design, Operation and Performance of an Expendable Temperature and Velocity Profiler (XTVP). Applied Physics Laboratory, University of Washington. Tech. Rep. No. APL-UW 8110, May 1982.

**Appendix**  
**XCP DATA PROFILES**

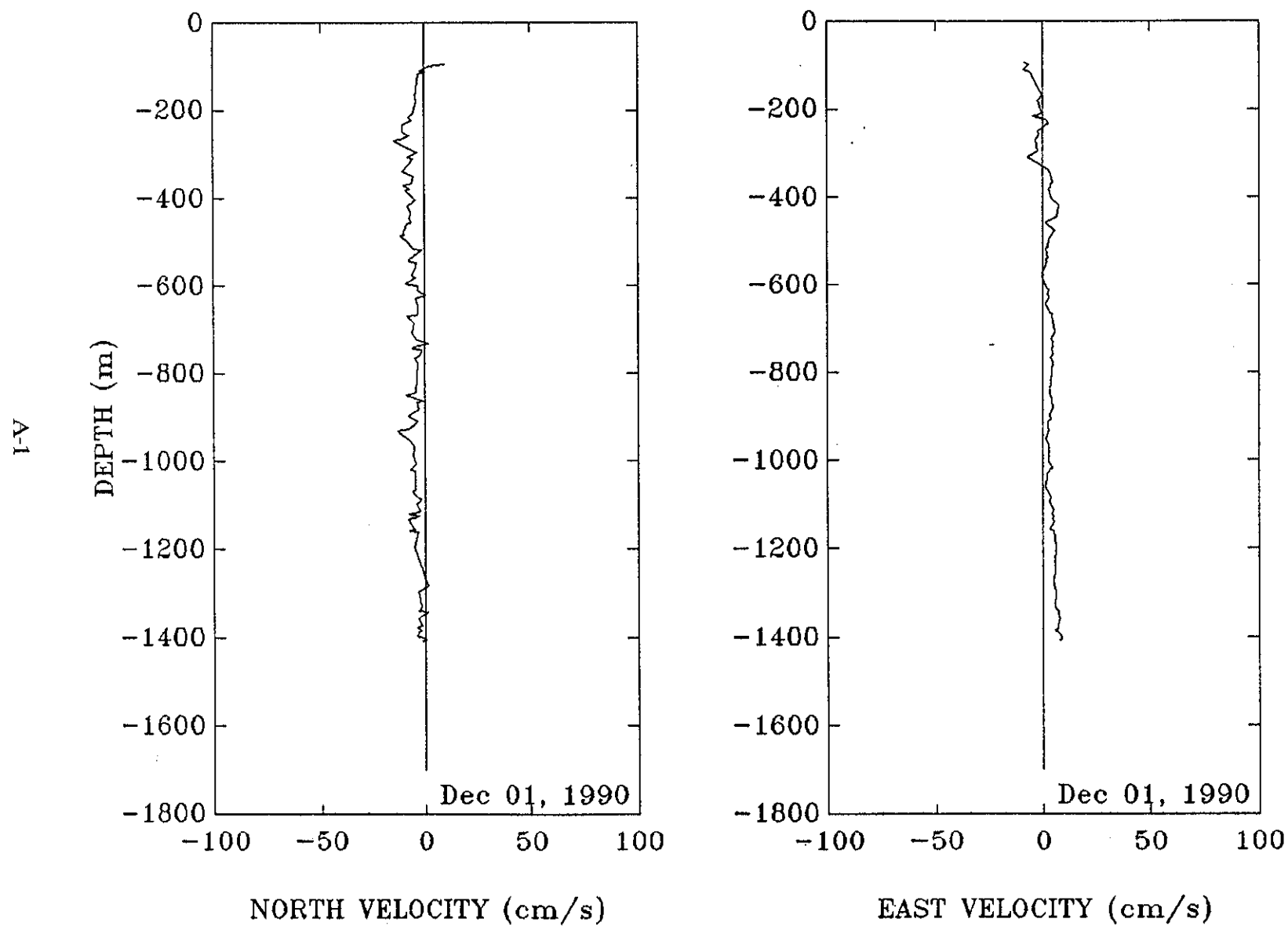


Figure A-1. XCP Profiles, Survey 30  
(a) Velocity Components Profile

A-2

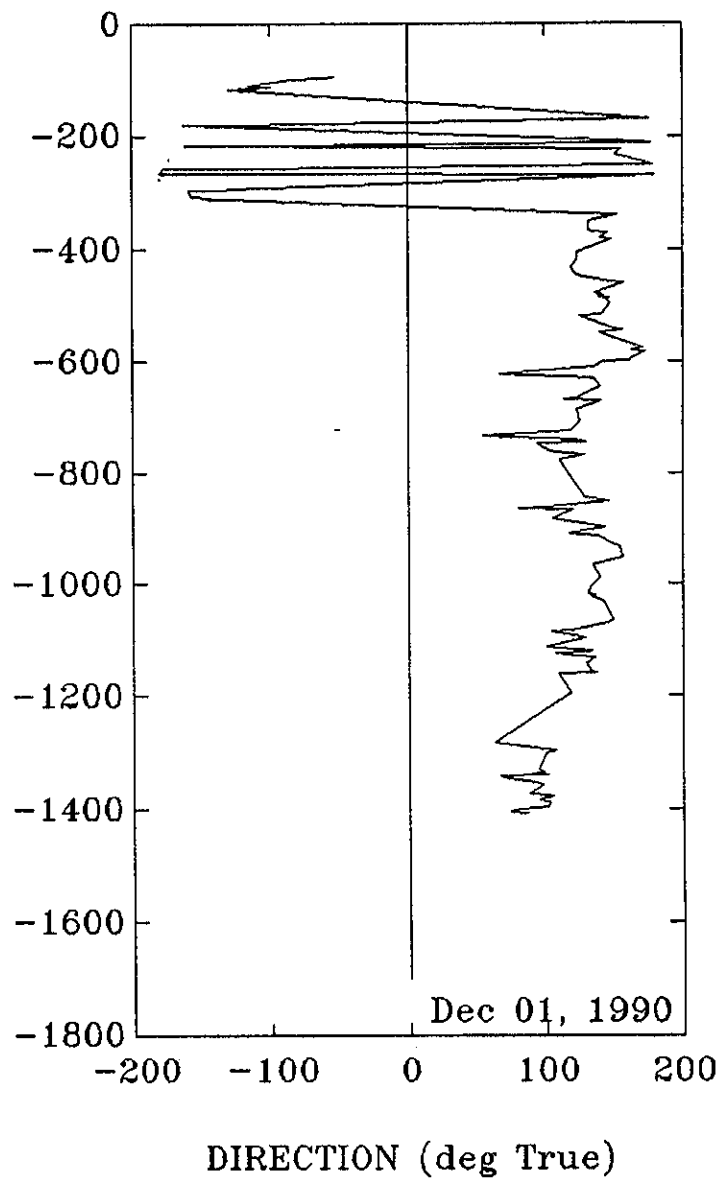
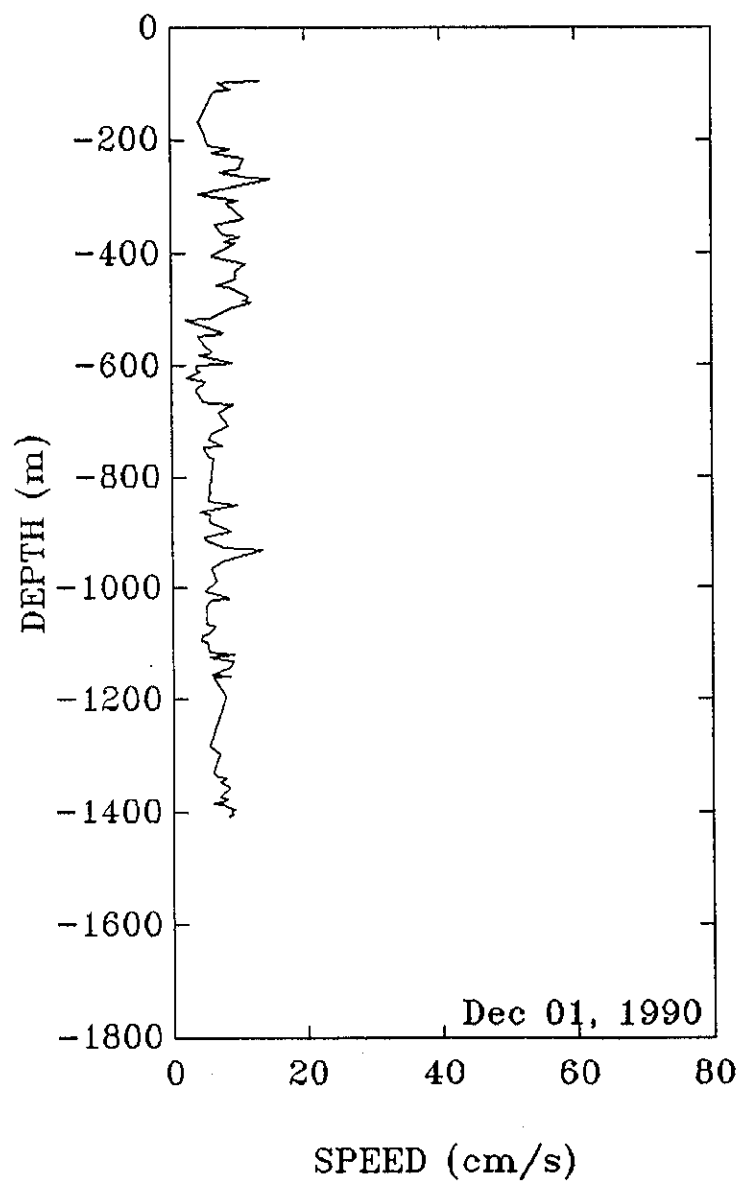


Figure A-1. XCP Profiles, Survey 30  
(b) Speed/Direction Profile

A-3

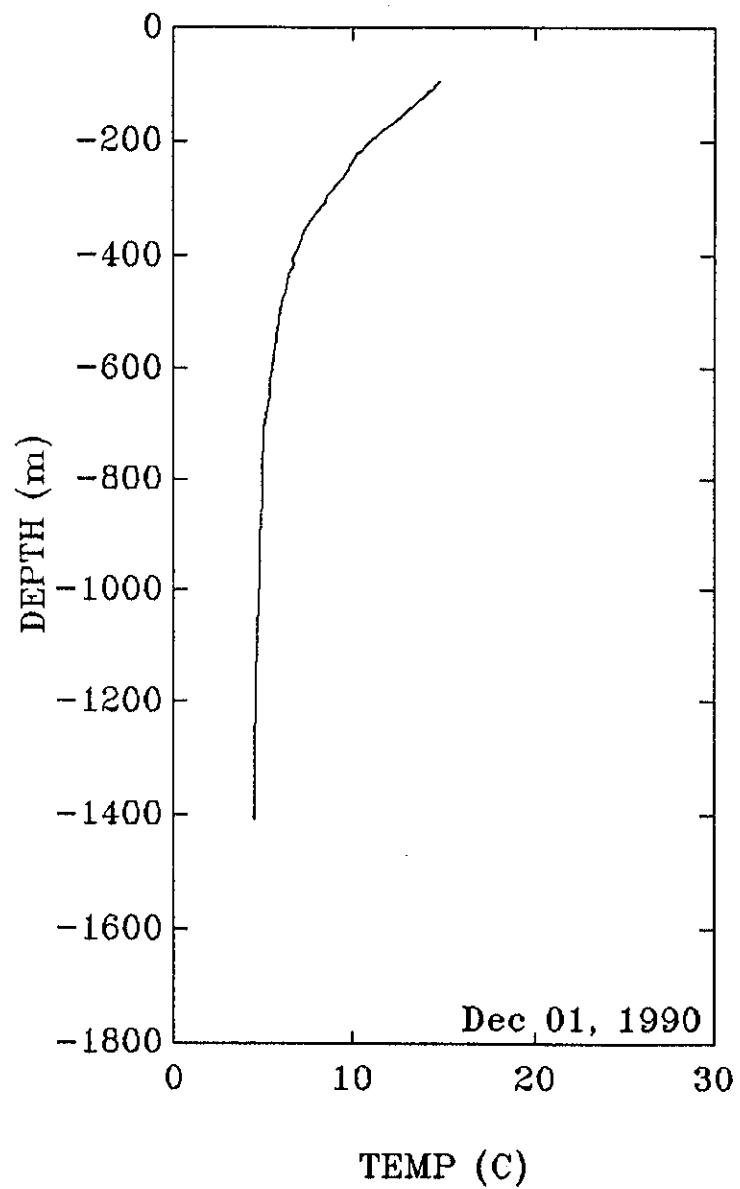


Figure A-1. XCP Profiles, Survey 30  
(c) Temperature Profile

A-4

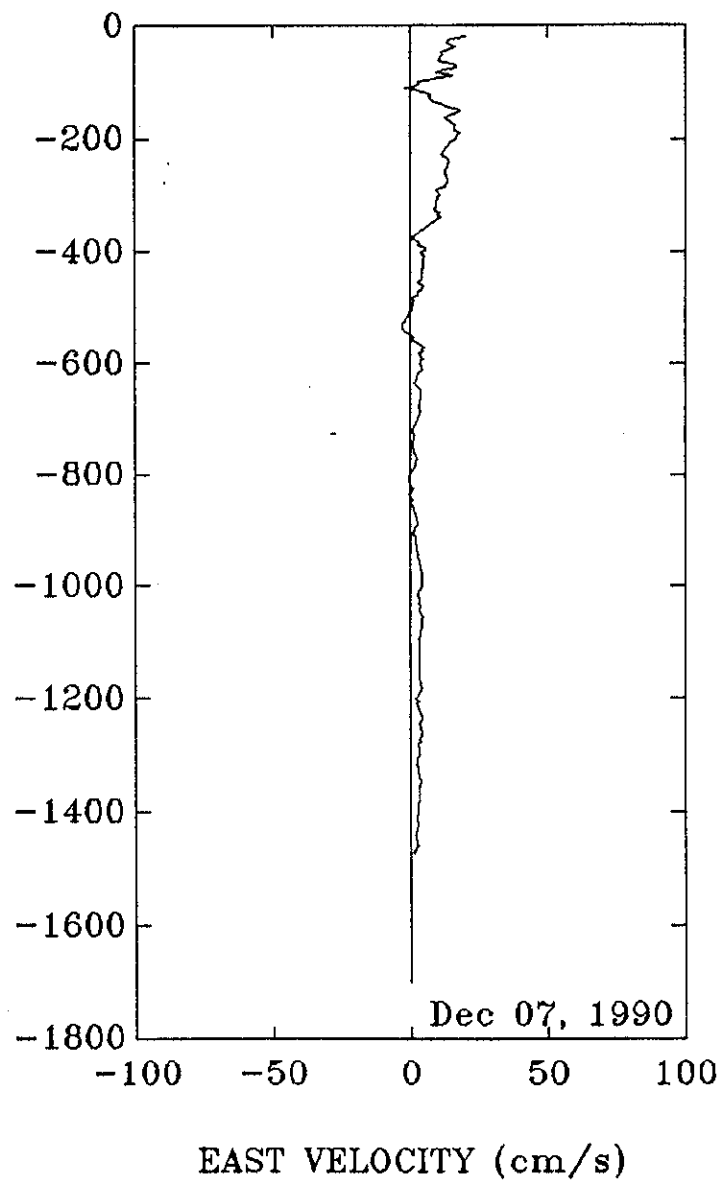
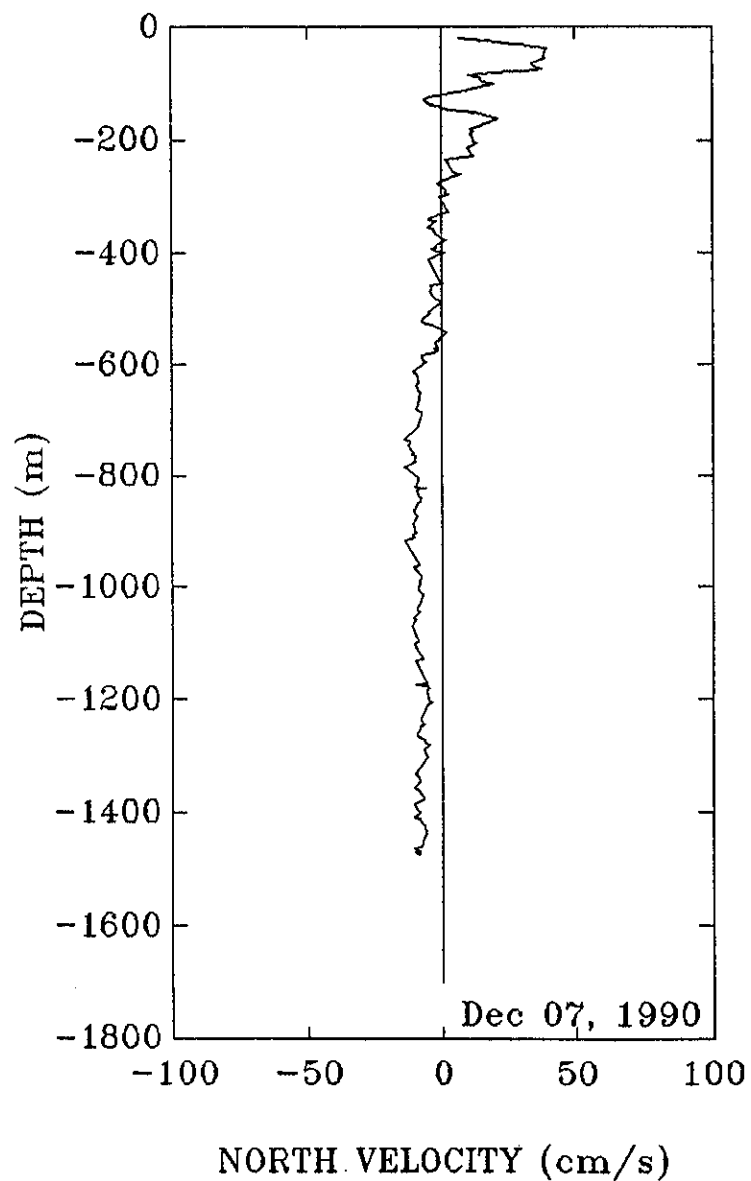


Figure A-2. XCP Profiles, Survey 31  
(a) Velocity Components Profile

A-5

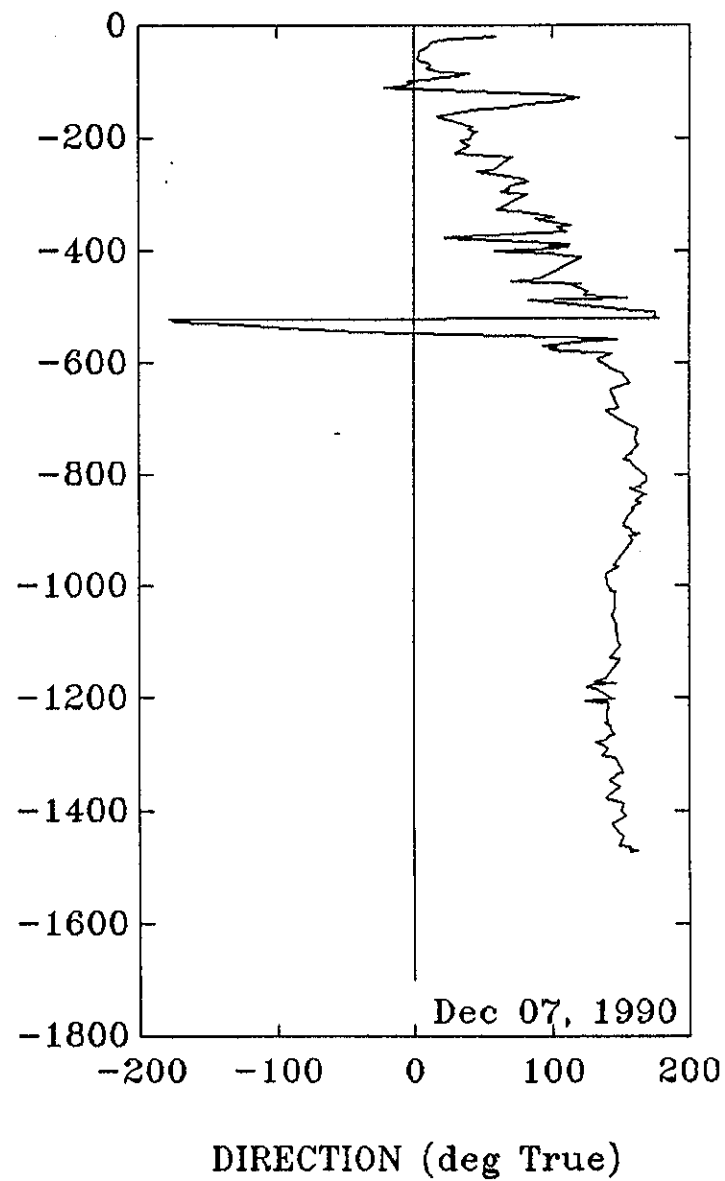
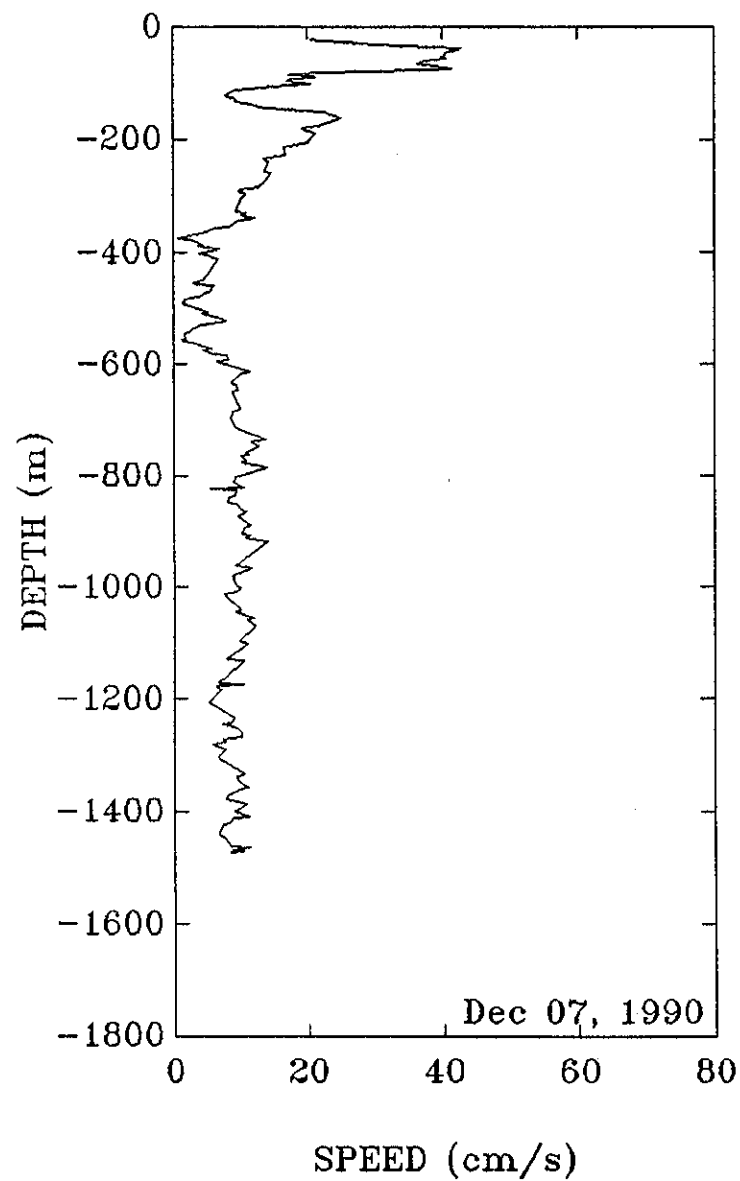


Figure A-2. XCP Profiles, Survey 31  
(b) Speed/Direction Profile

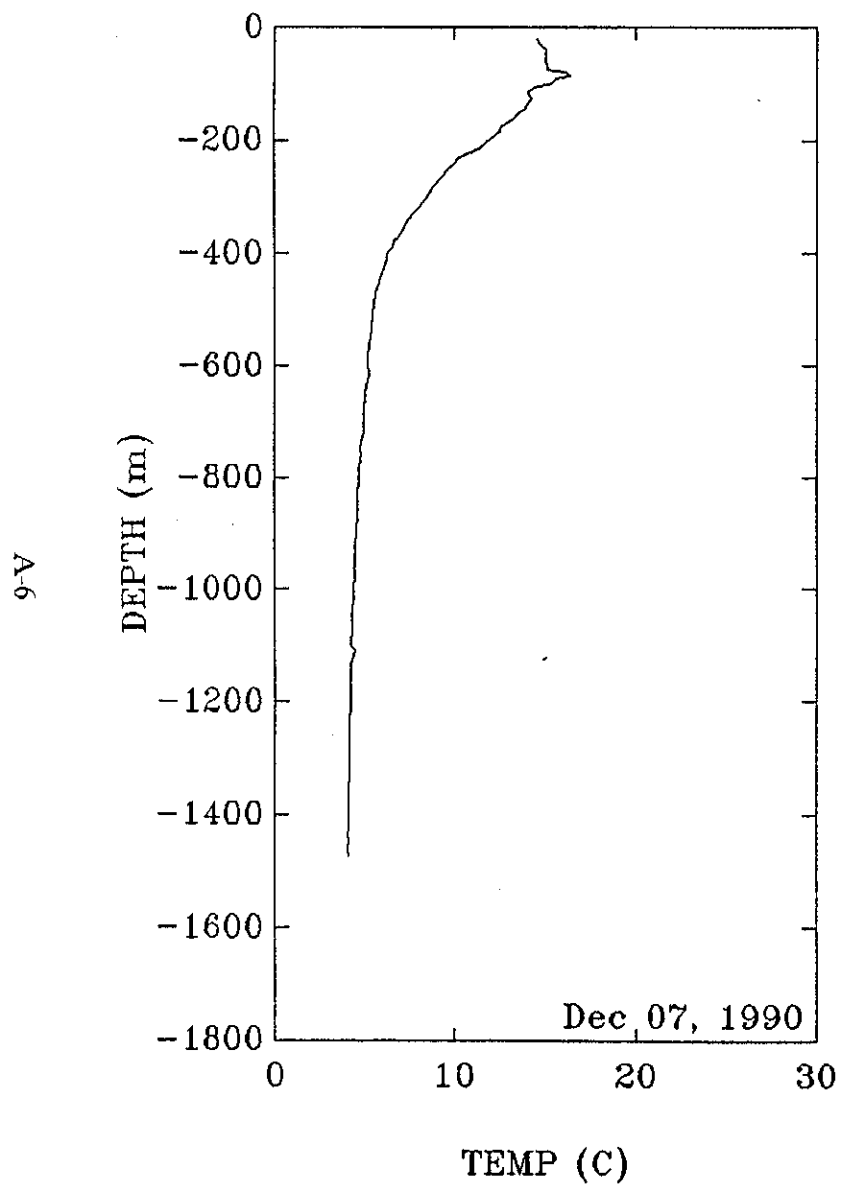


Figure A-2. XCP Profiles, Survey 31  
(c) Temperature Profile

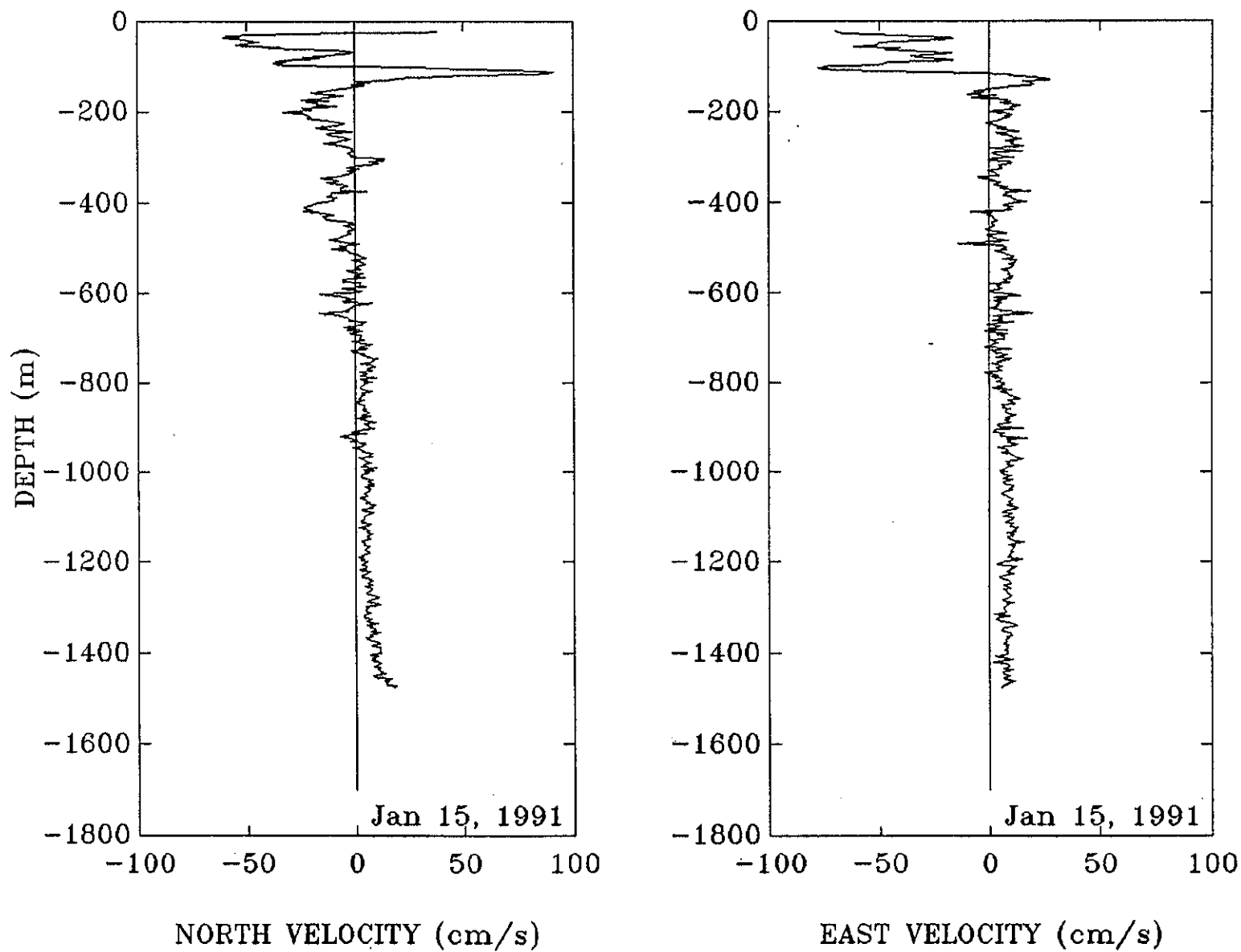


Figure A-3. XCP Profiles, Survey 32  
(a) Velocity Components Profile

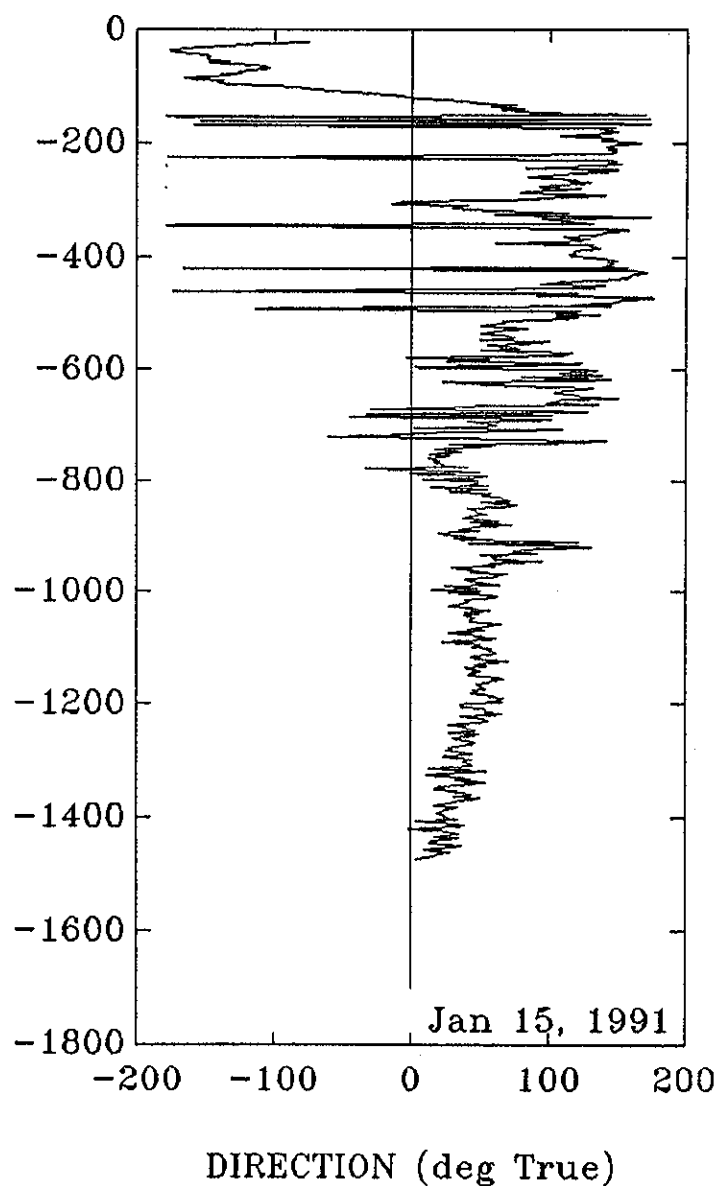
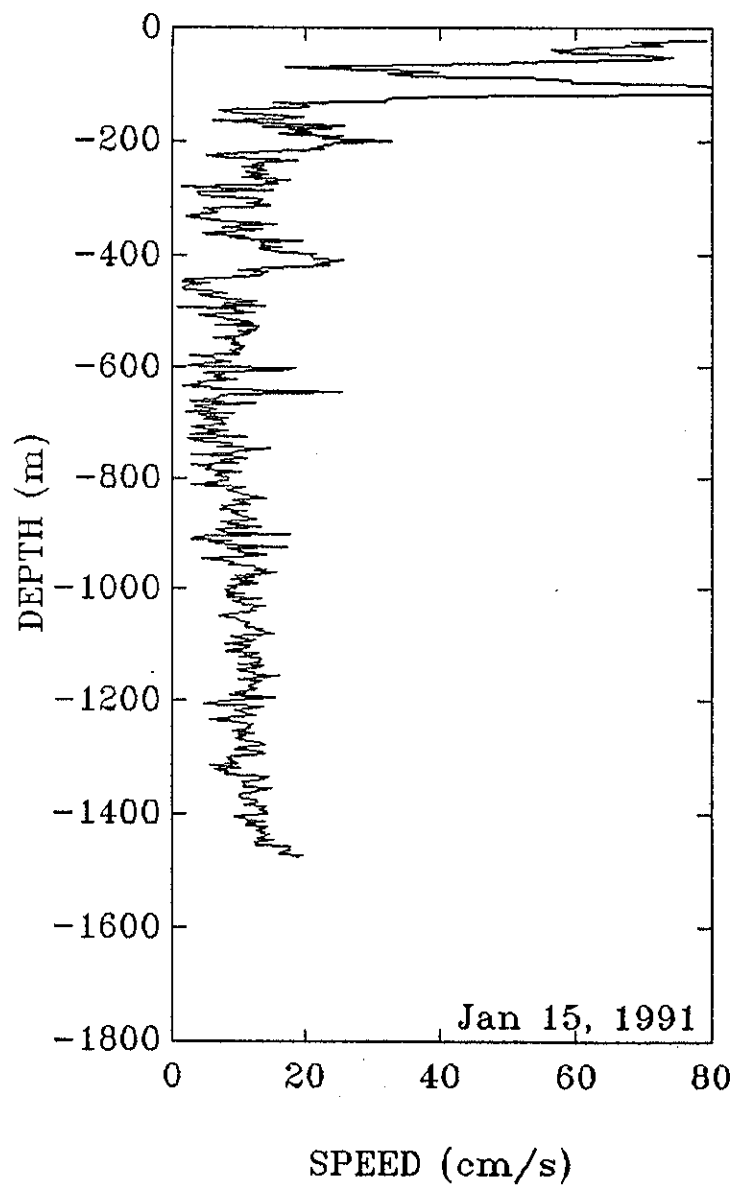


Figure A-3. XCP Profiles, Survey 32  
(b) Speed/Direction Profile

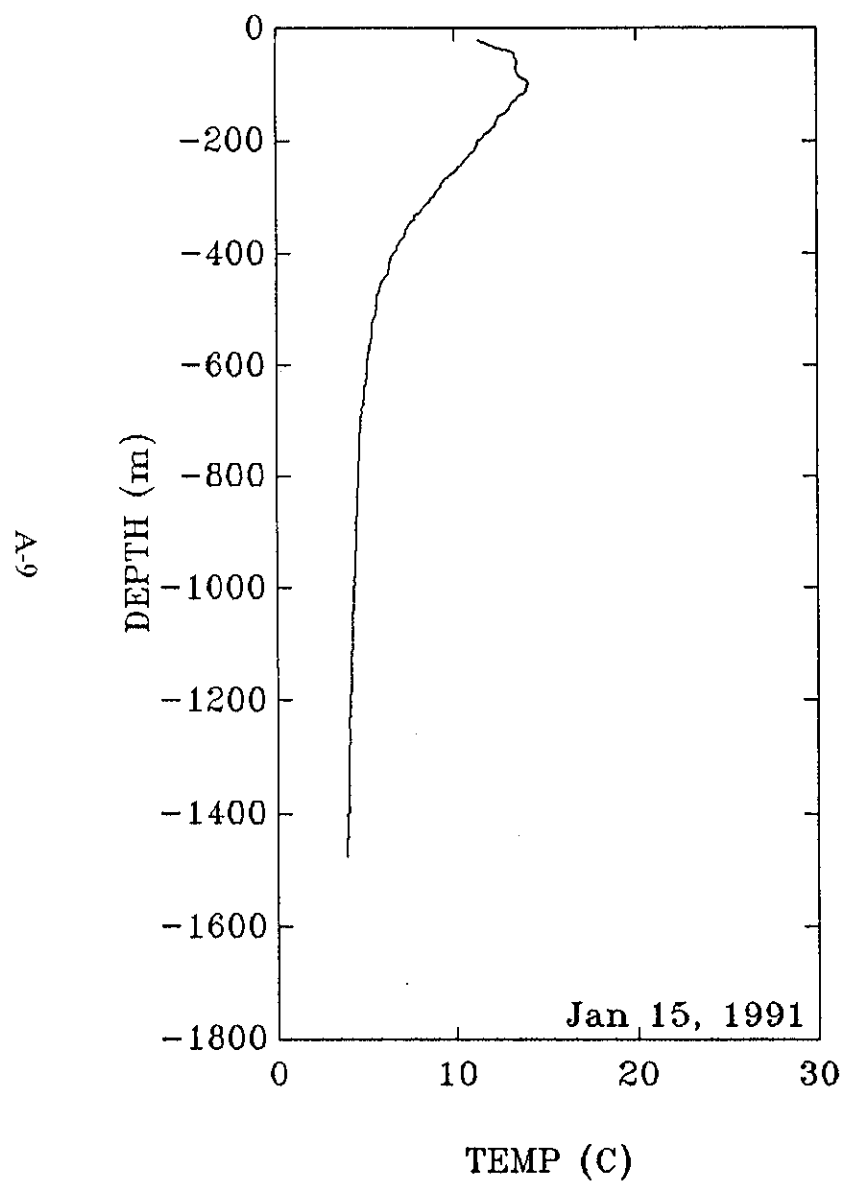


Figure A-3. XCP Profiles, Survey 32  
(c) Temperature Profile

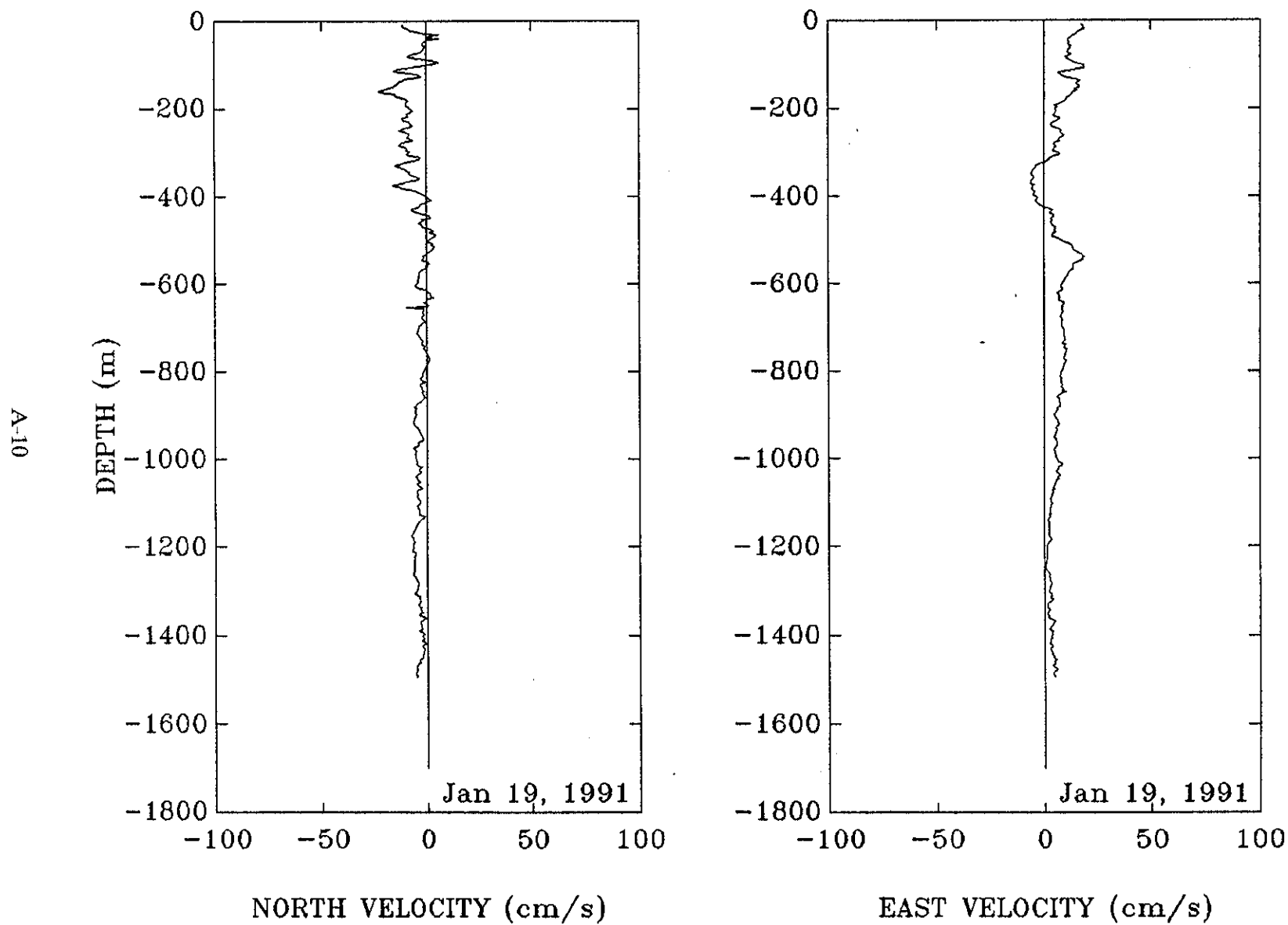


Figure A-4. XCP Profiles, Survey 33  
(a) Velocity Components Profile

A-11

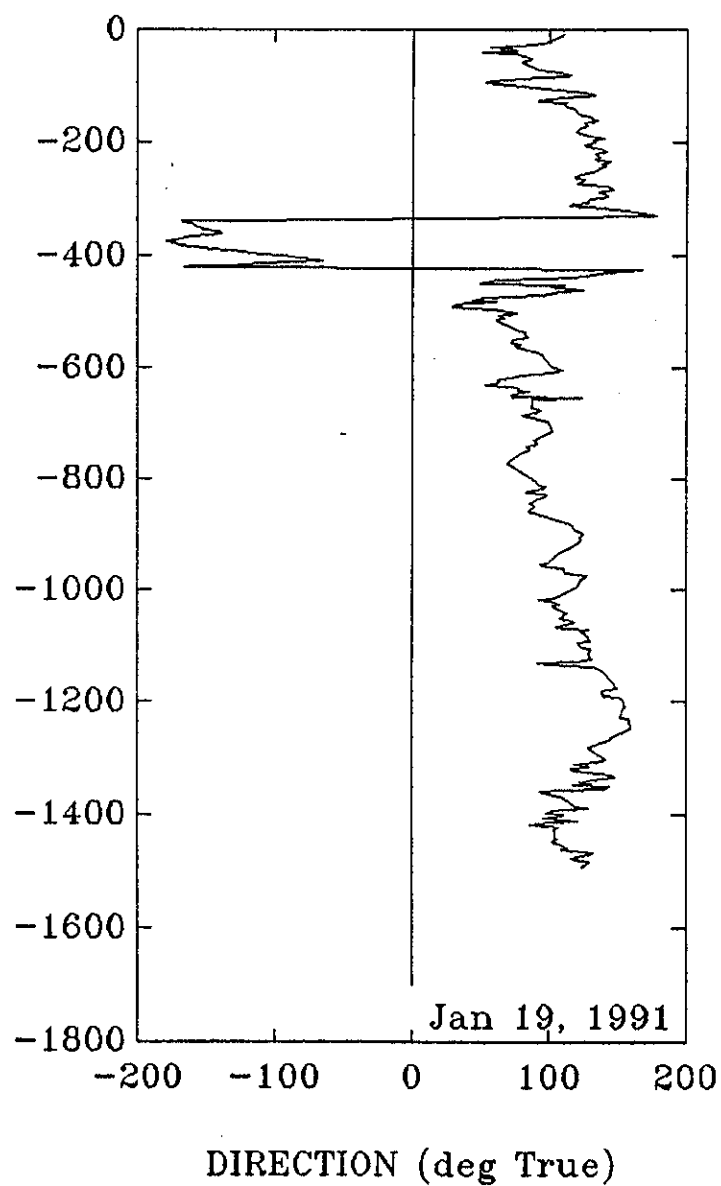
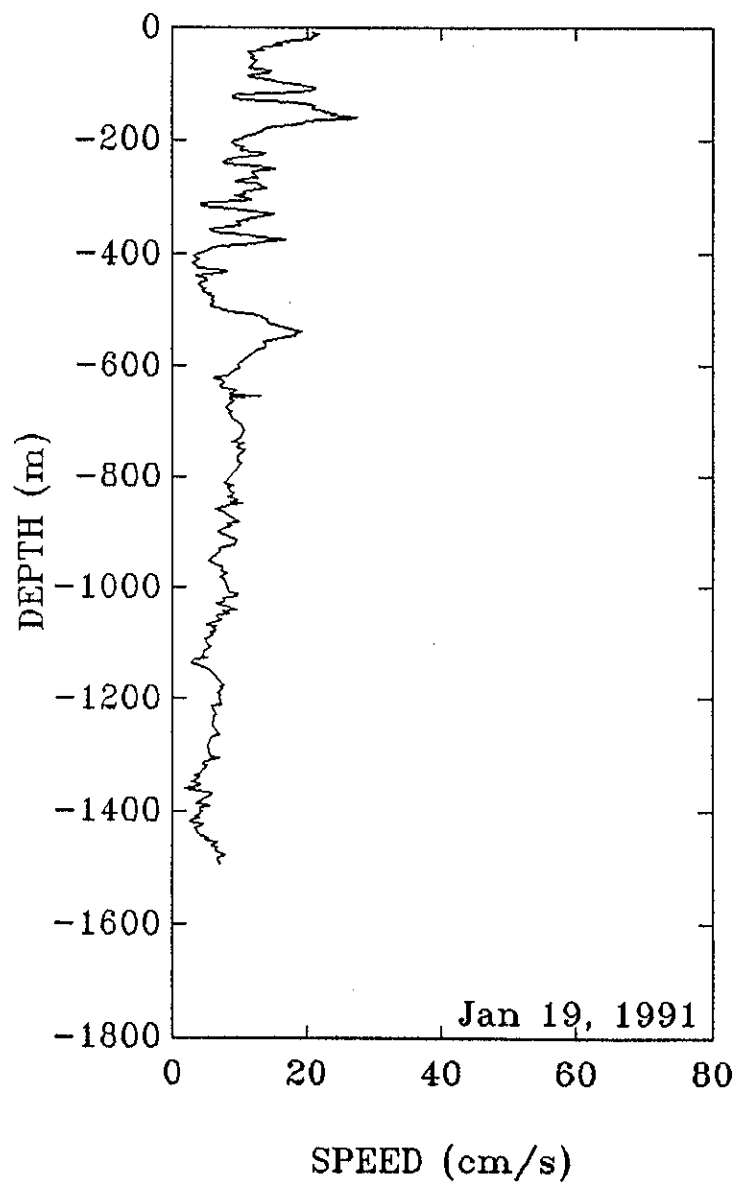


Figure A-4. XCP Profiles, Survey 33  
(b) Speed/Direction Profile

A-12

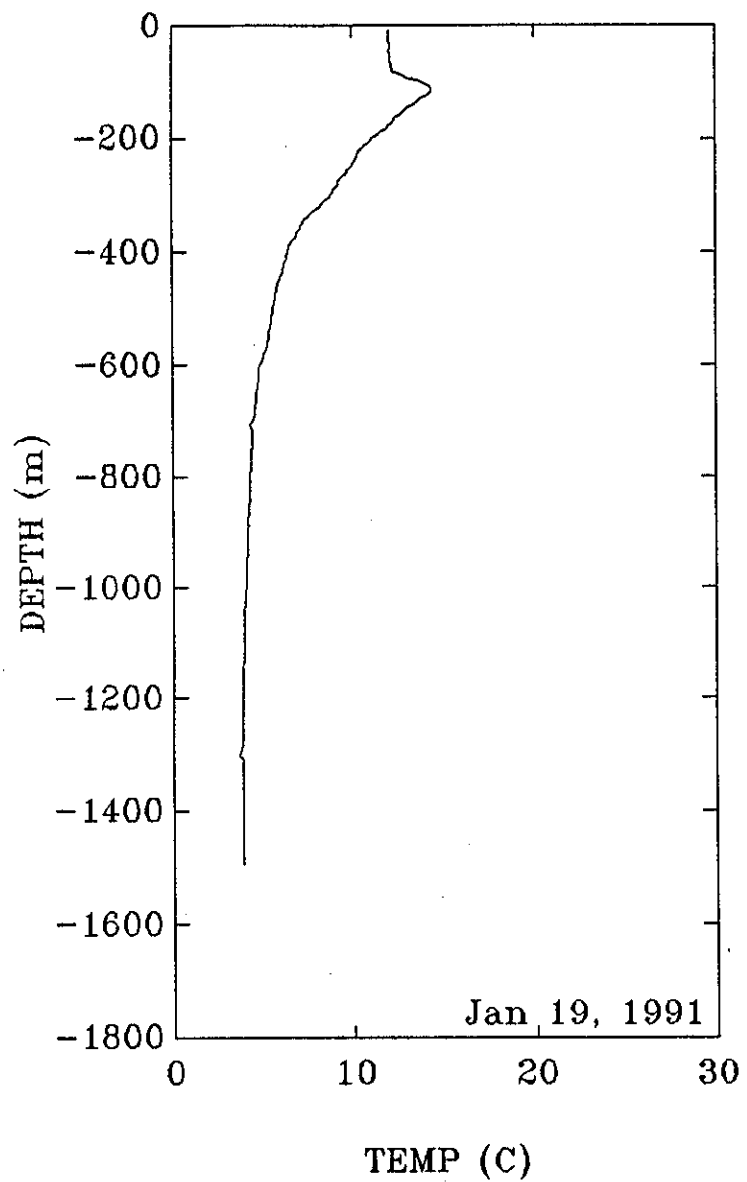


Figure A-4. XCP Profiles, Survey 33  
(c) Temperature Profile

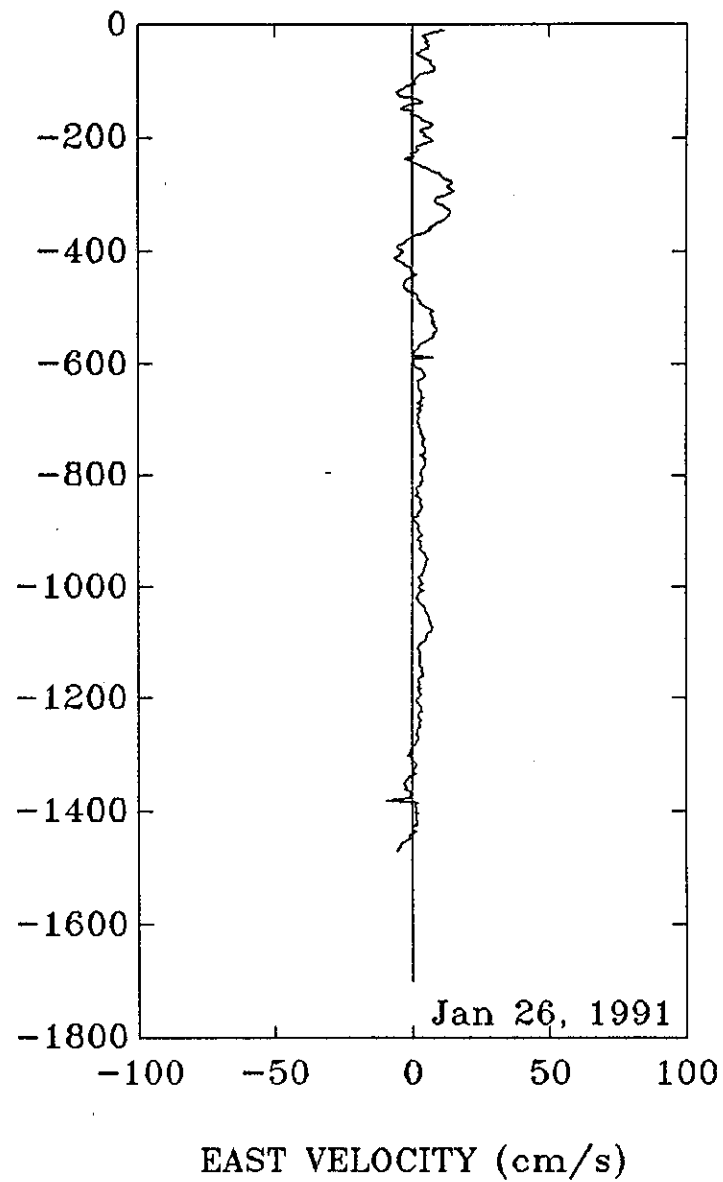
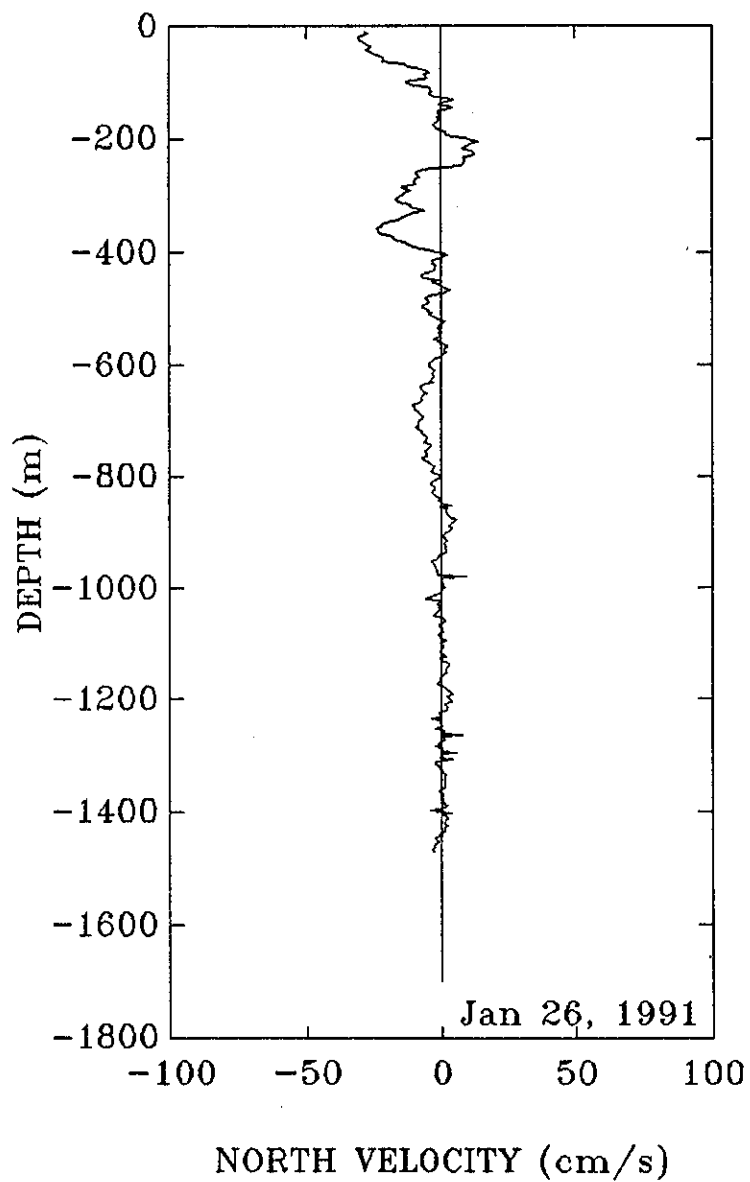


Figure A-5. XCP Profiles, Survey 34  
(a) Velocity Components Profile

A-14

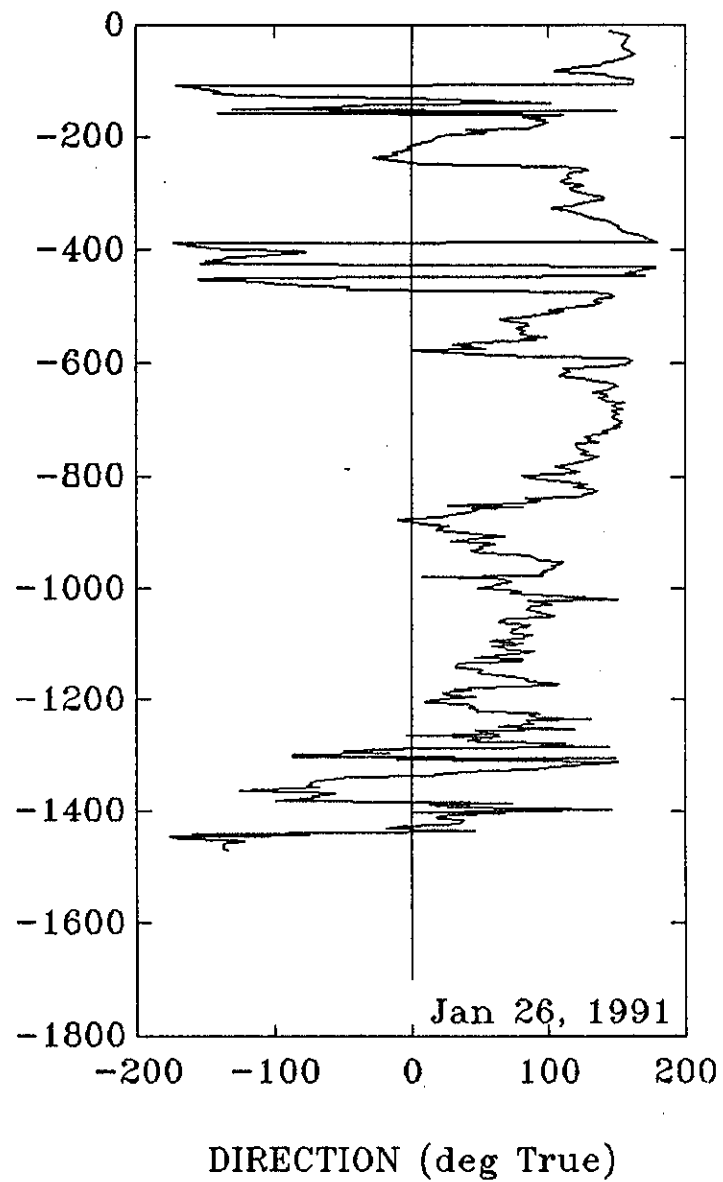
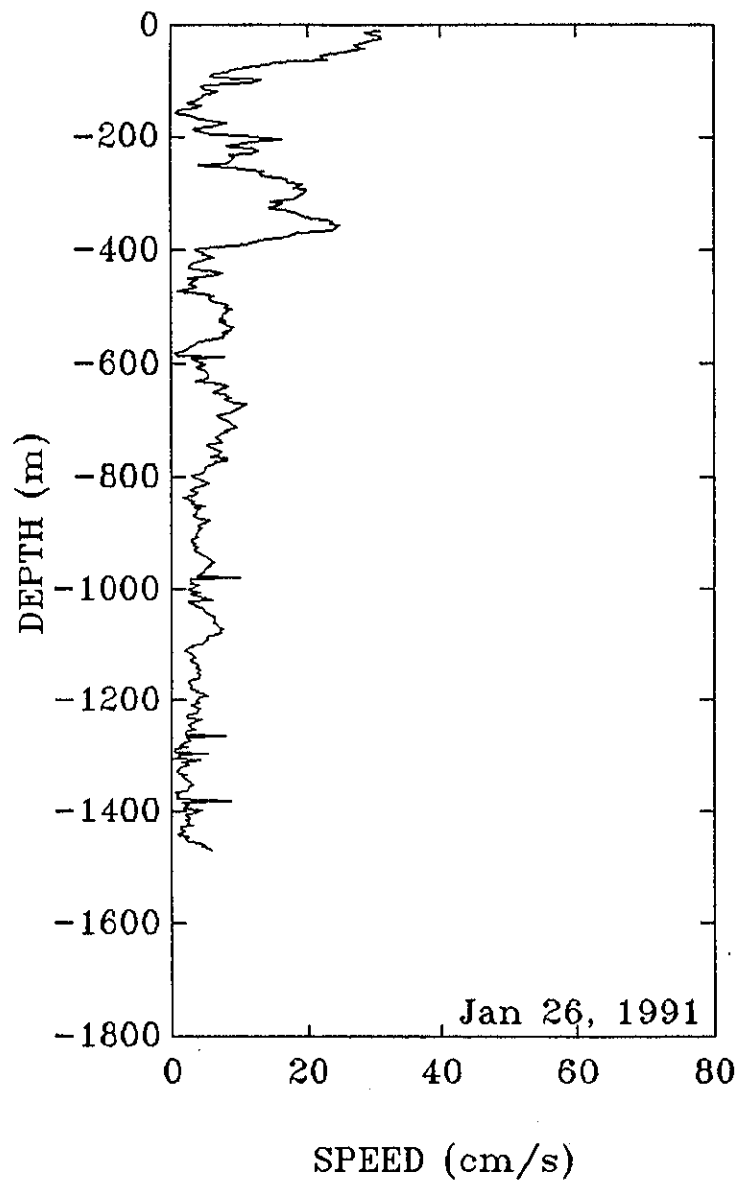


Figure A-5. XCP Profiles, Survey 34  
(b) Speed/Direction Profile

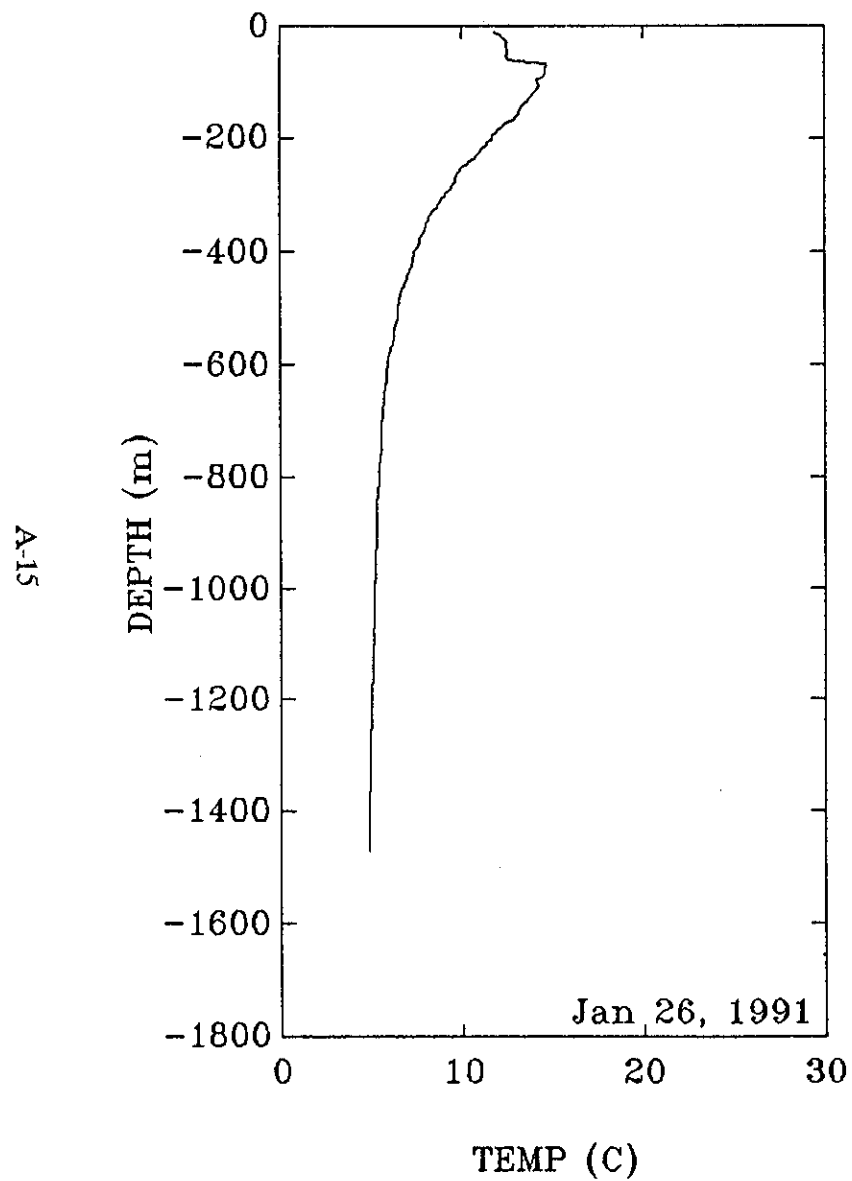


Figure A-5. XCP Profiles, Survey 34  
(c) Temperature Profile

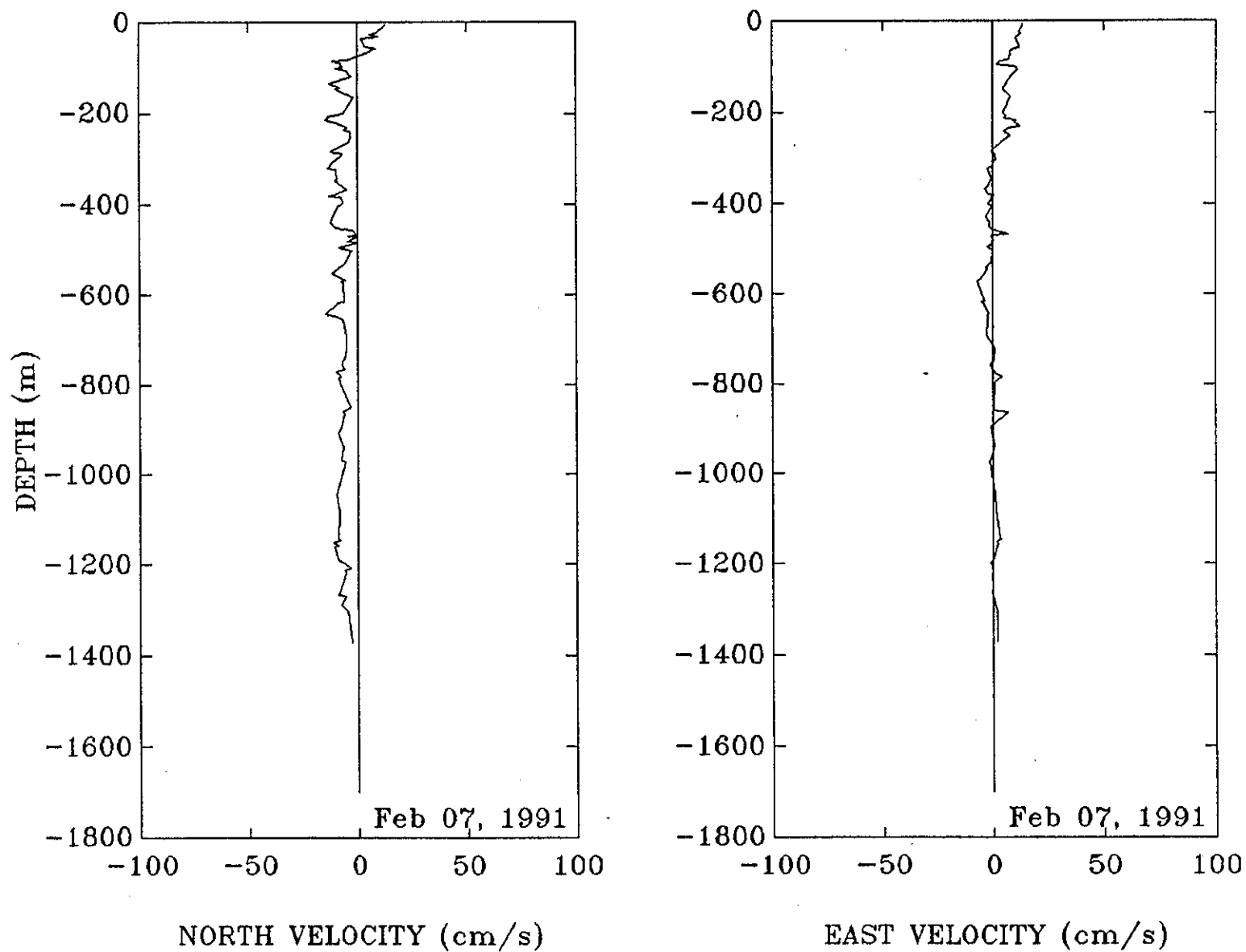


Figure A-6. XCP Profiles, Survey 36  
(a) Velocity Components Profile

A-17

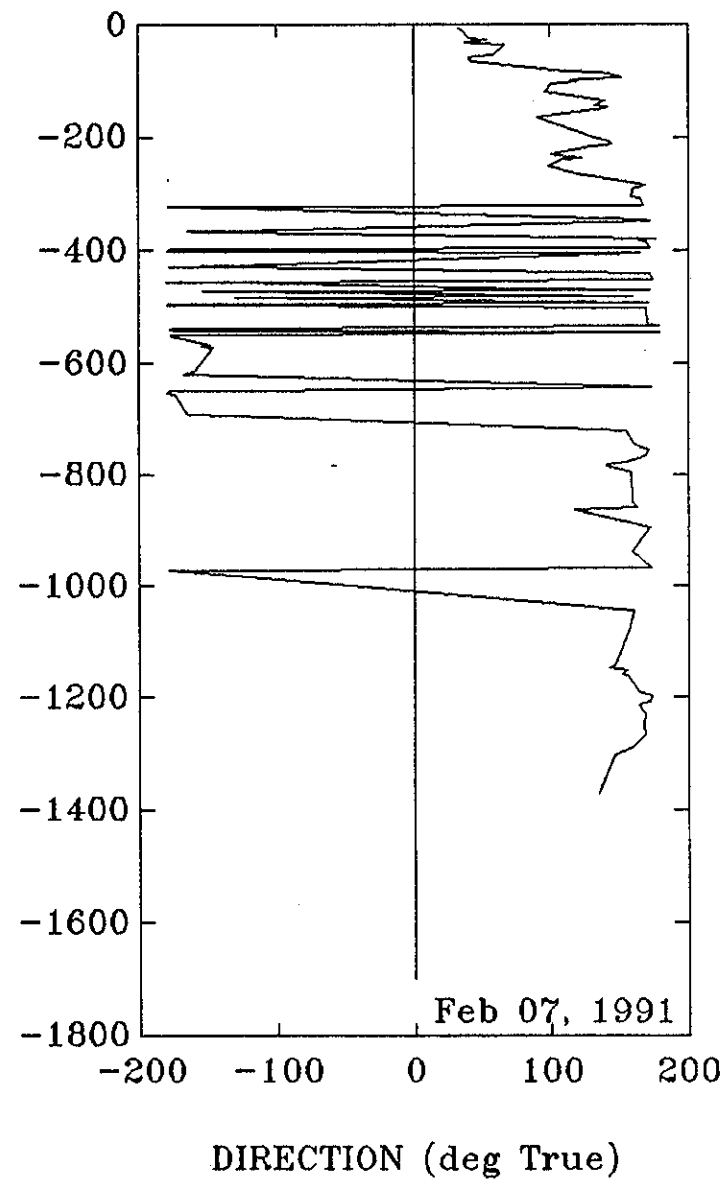
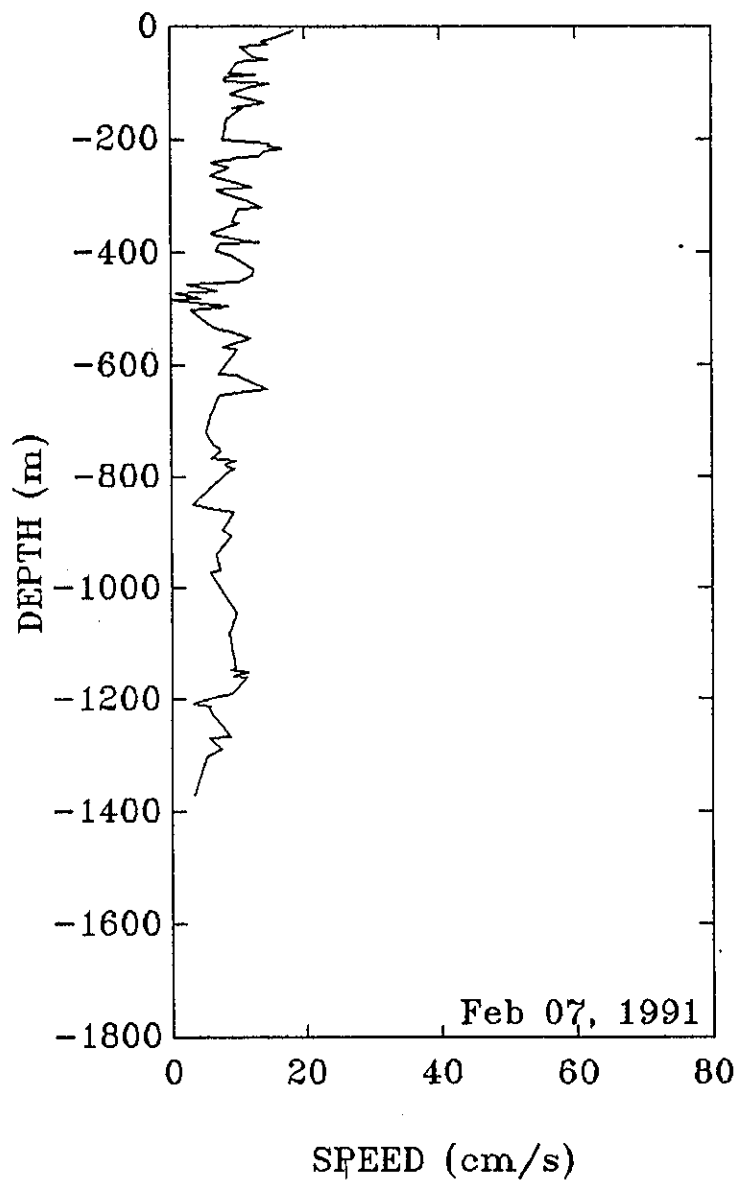


Figure A-6. XCP Profiles, Survey 36  
(b) Speed/Direction Profile

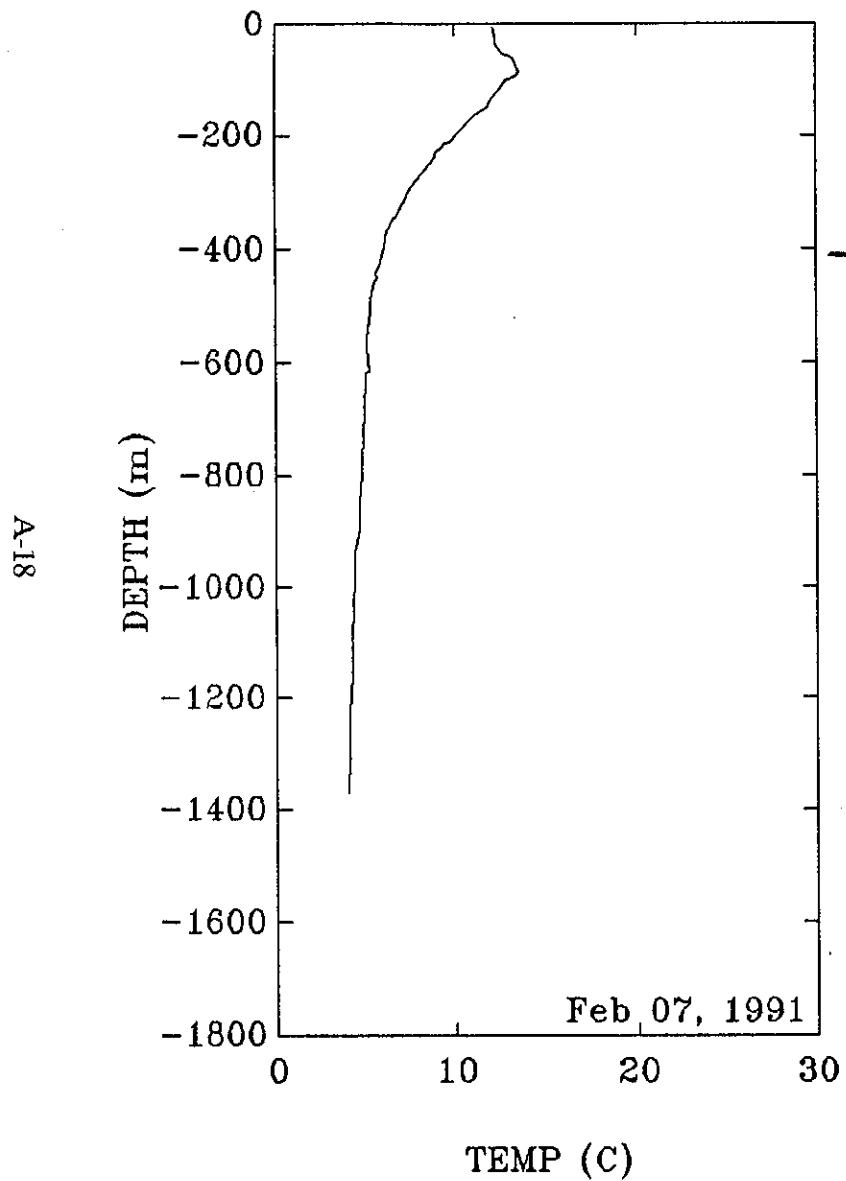


Figure A-6. XCP Profiles, Survey 36  
(c) Temperature Profile

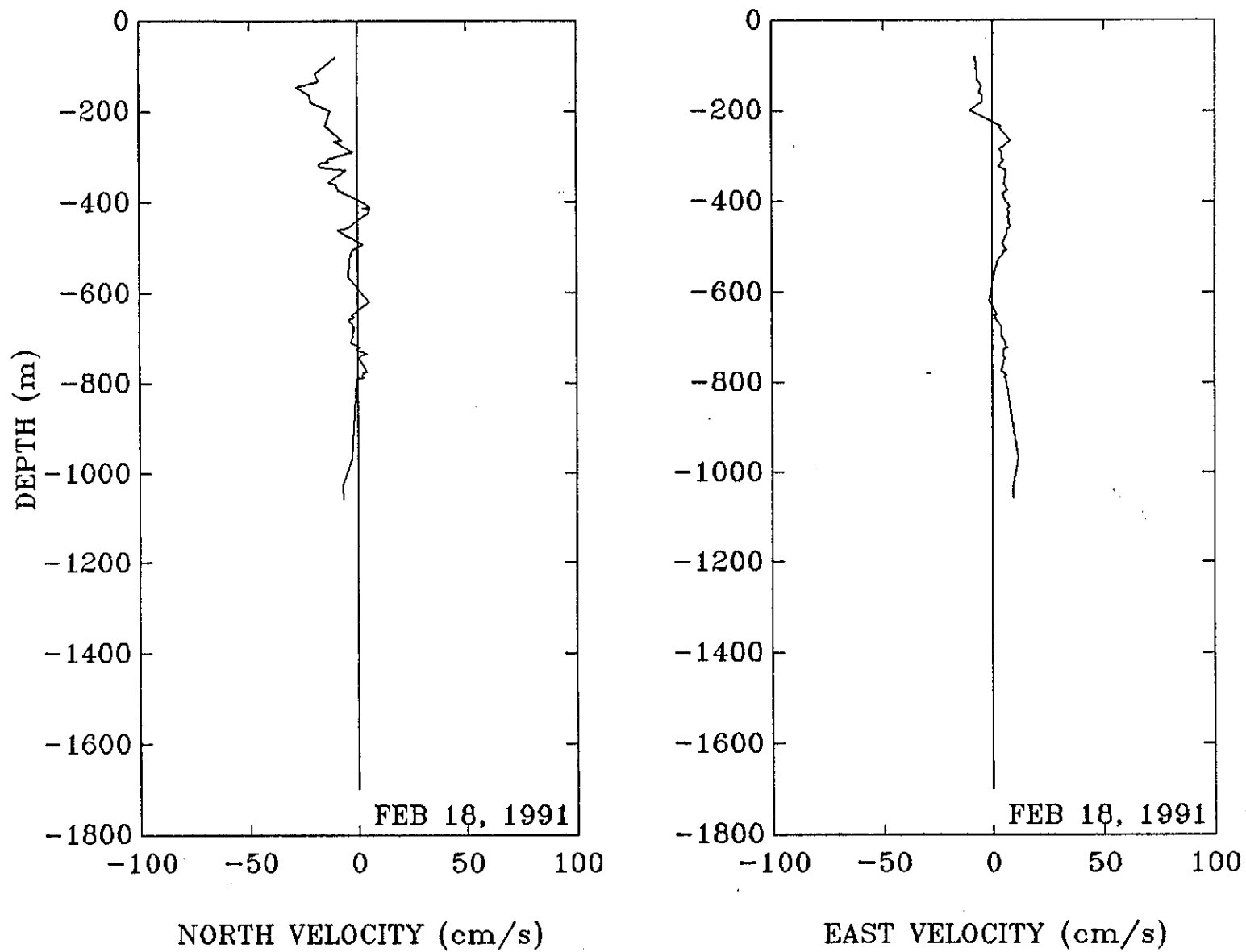


Figure A-7. XCP Profiles, Survey 37  
(a) Velocity Components Profile

A-20

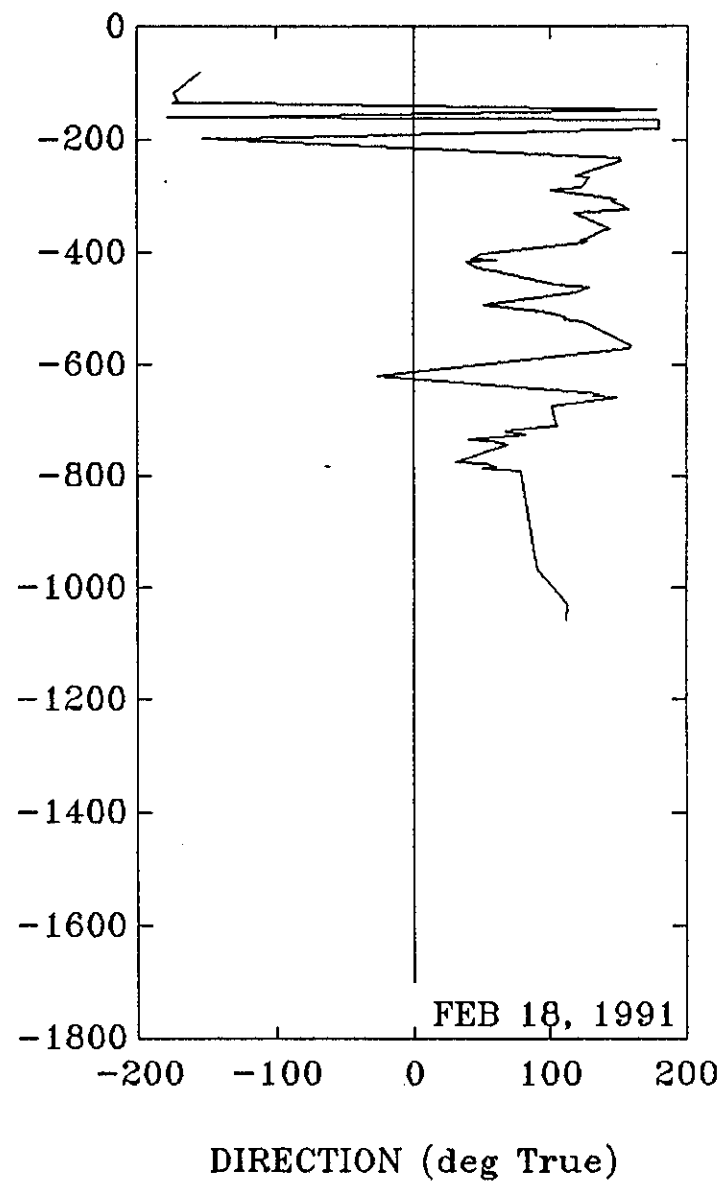
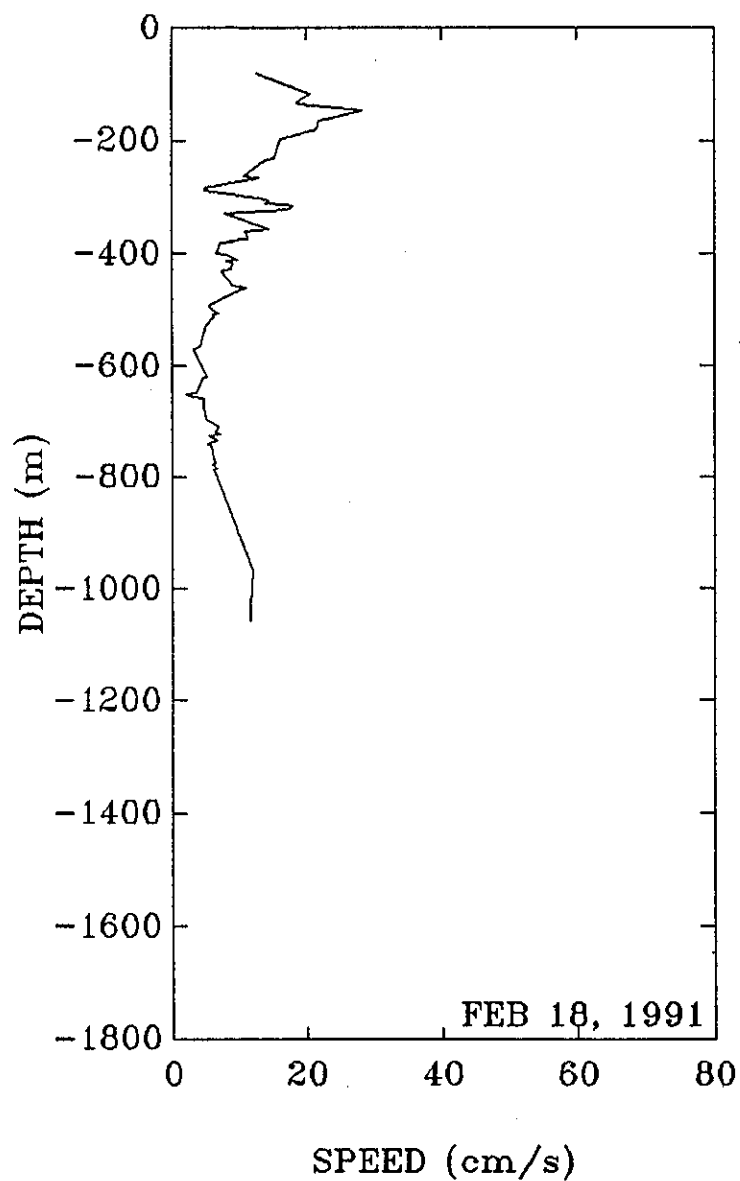


Figure A-7. XCP Profiles, Survey 37  
(b) Speed/Direction Profile

A-21

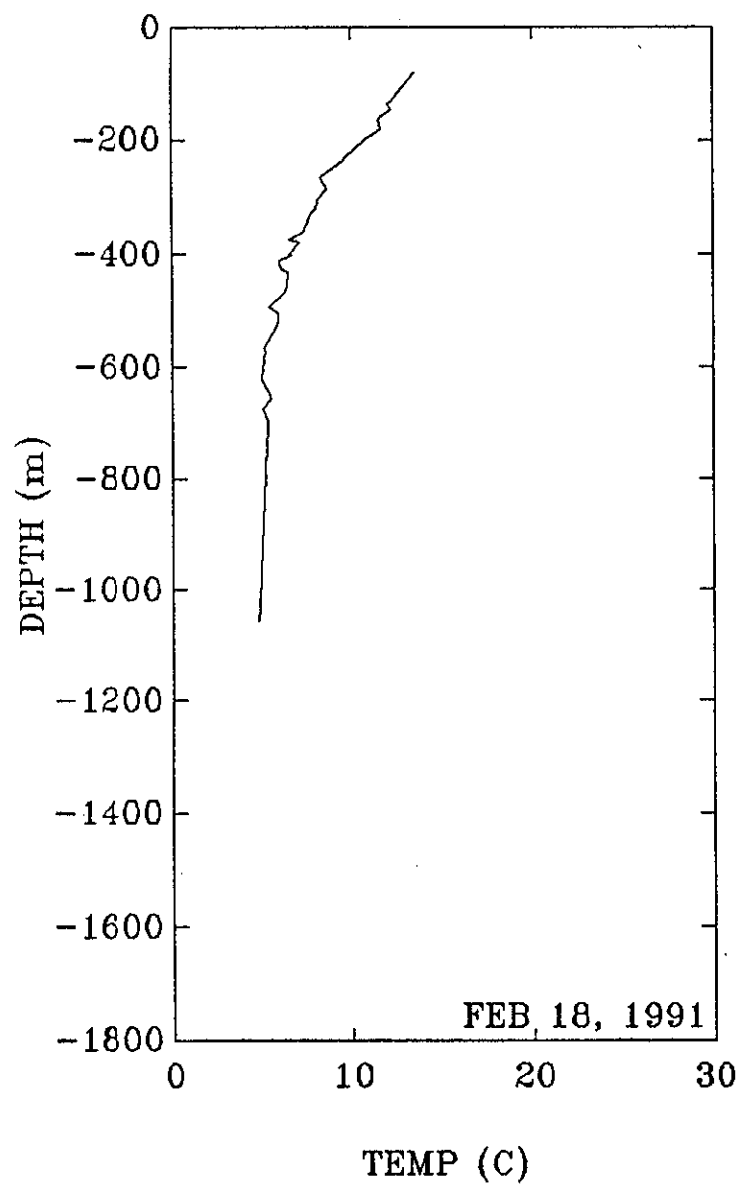


Figure A-7. XCP Profiles, Survey 37  
(c) Temperature Profile

A-22

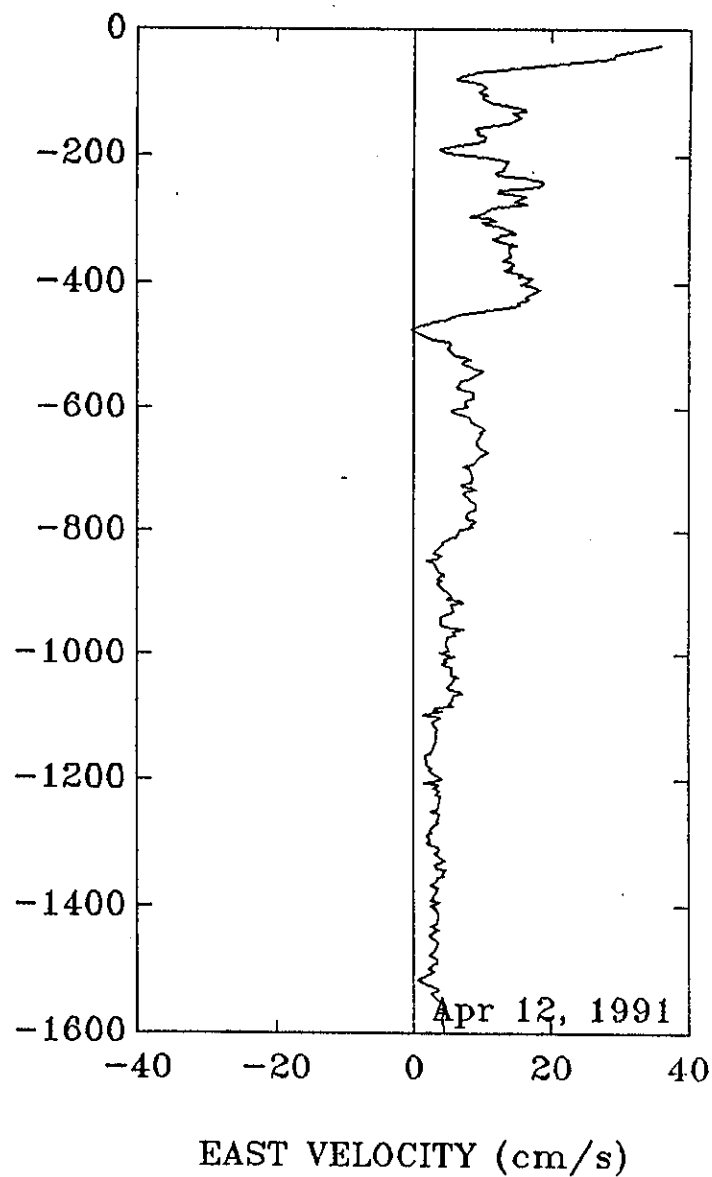
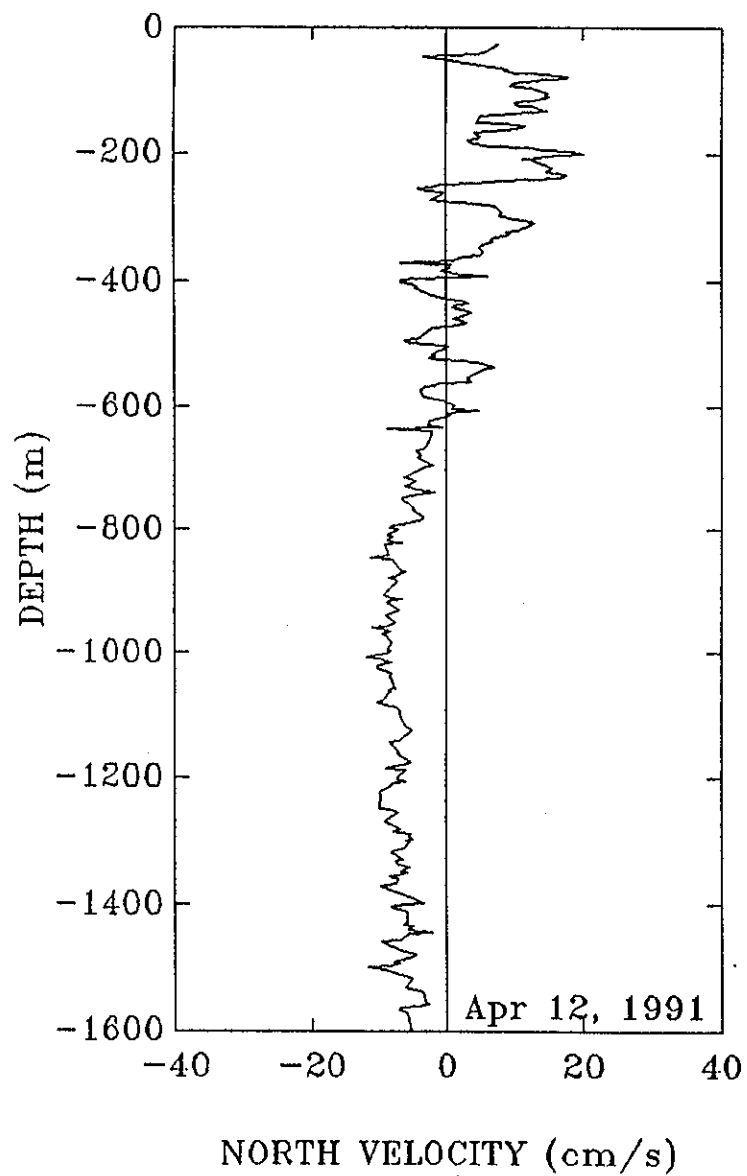


Figure A-8. XCP Profiles, Survey 39a  
(a) Velocity Components Profile

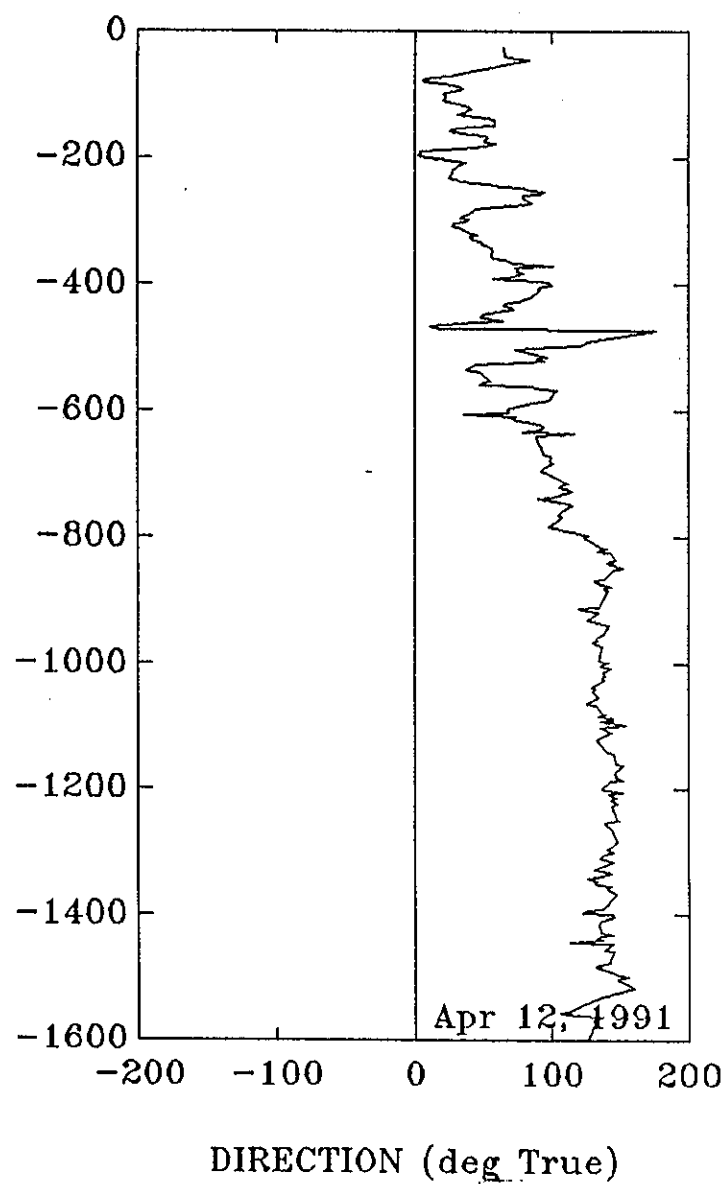
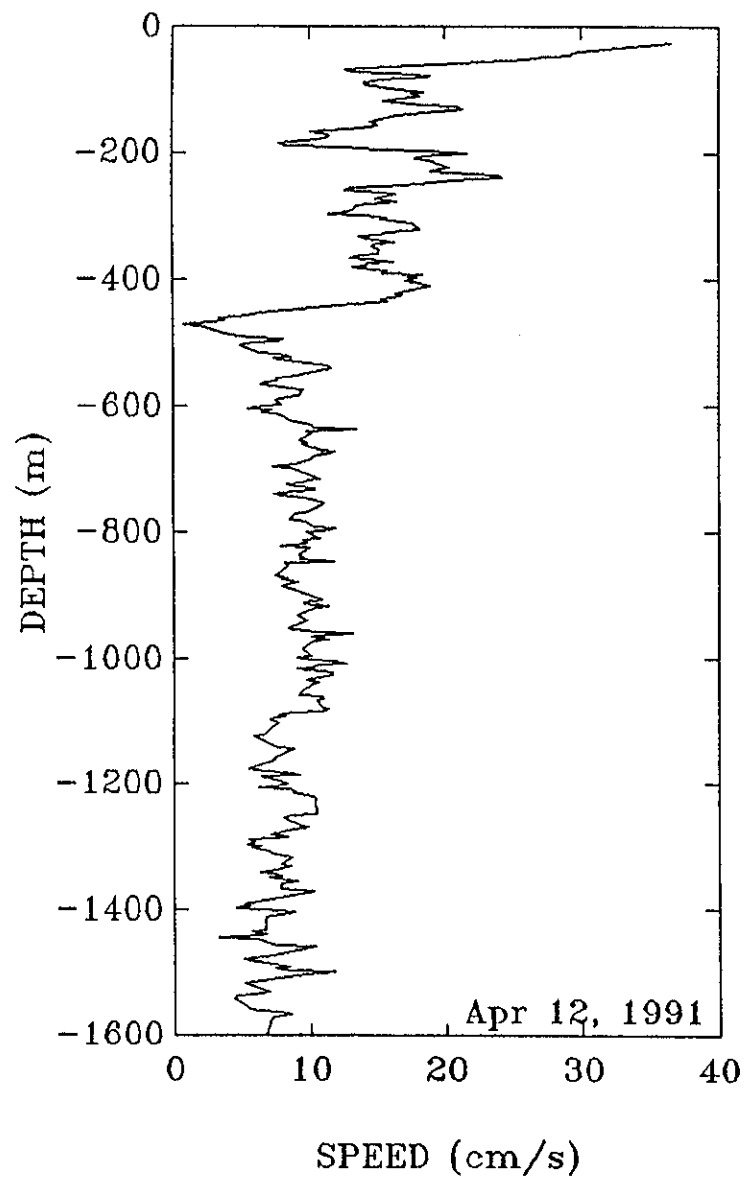


Figure A-8. XCP Profiles, Survey 39a  
(b) Speed/Direction Profile

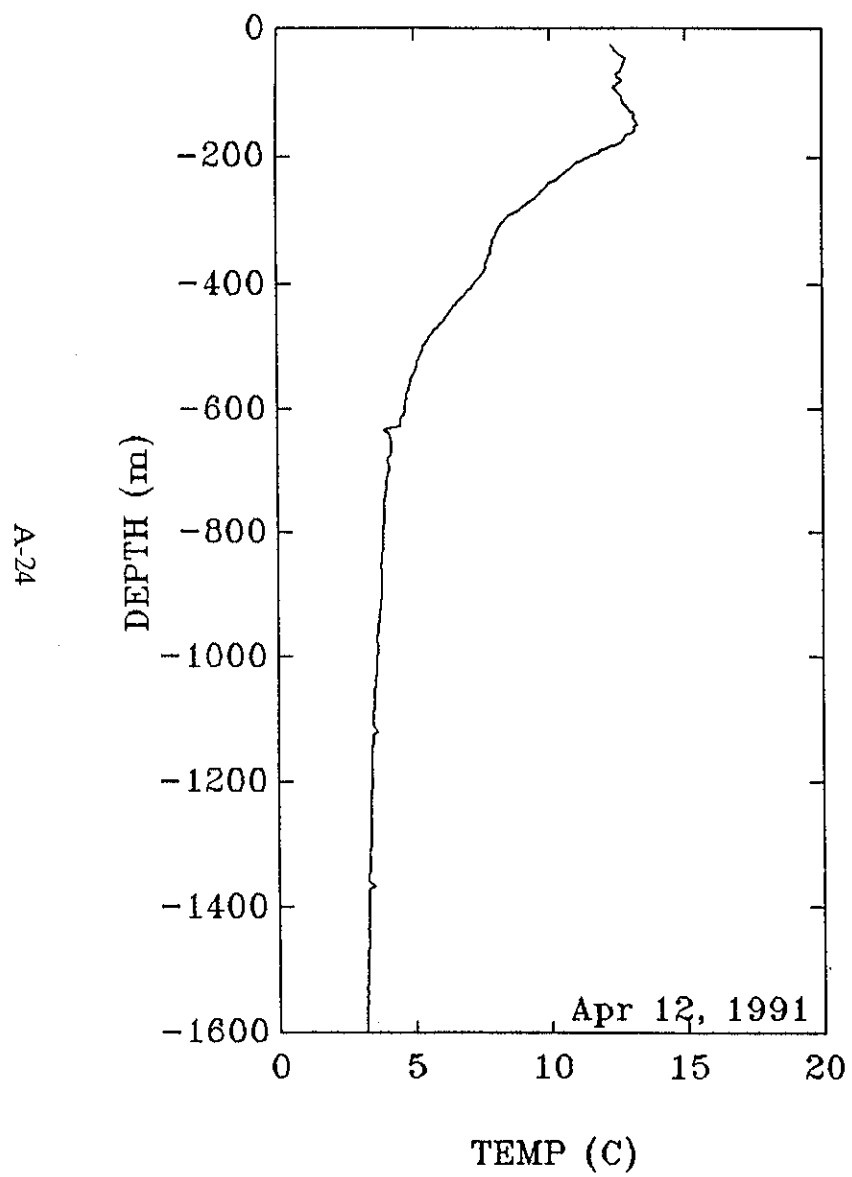


Figure A-8. XCP Profiles, Survey 39a  
(c) Temperature Profile

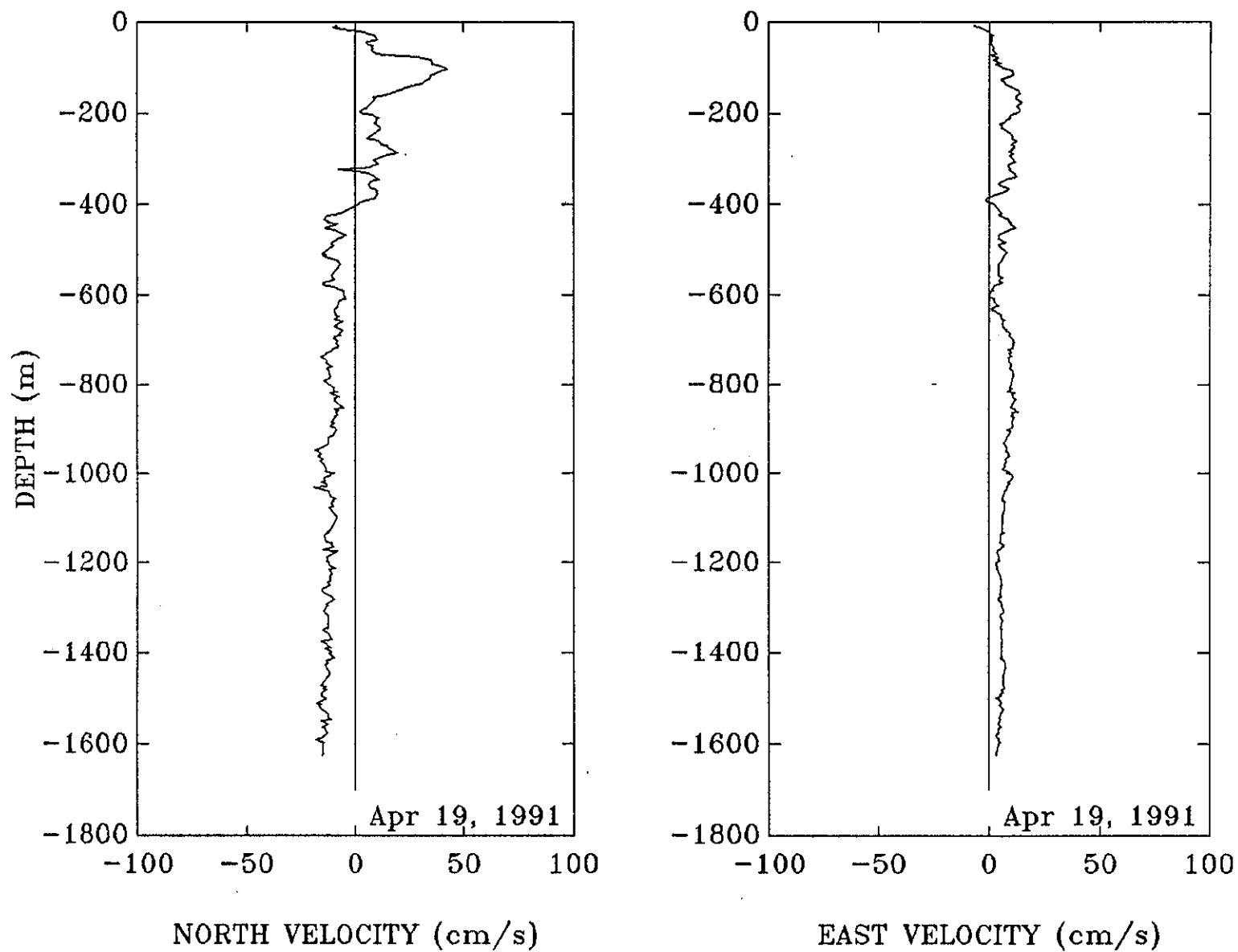


Figure A-9. XCP Profiles, Survey 40a  
(a) Velocity Components Profile

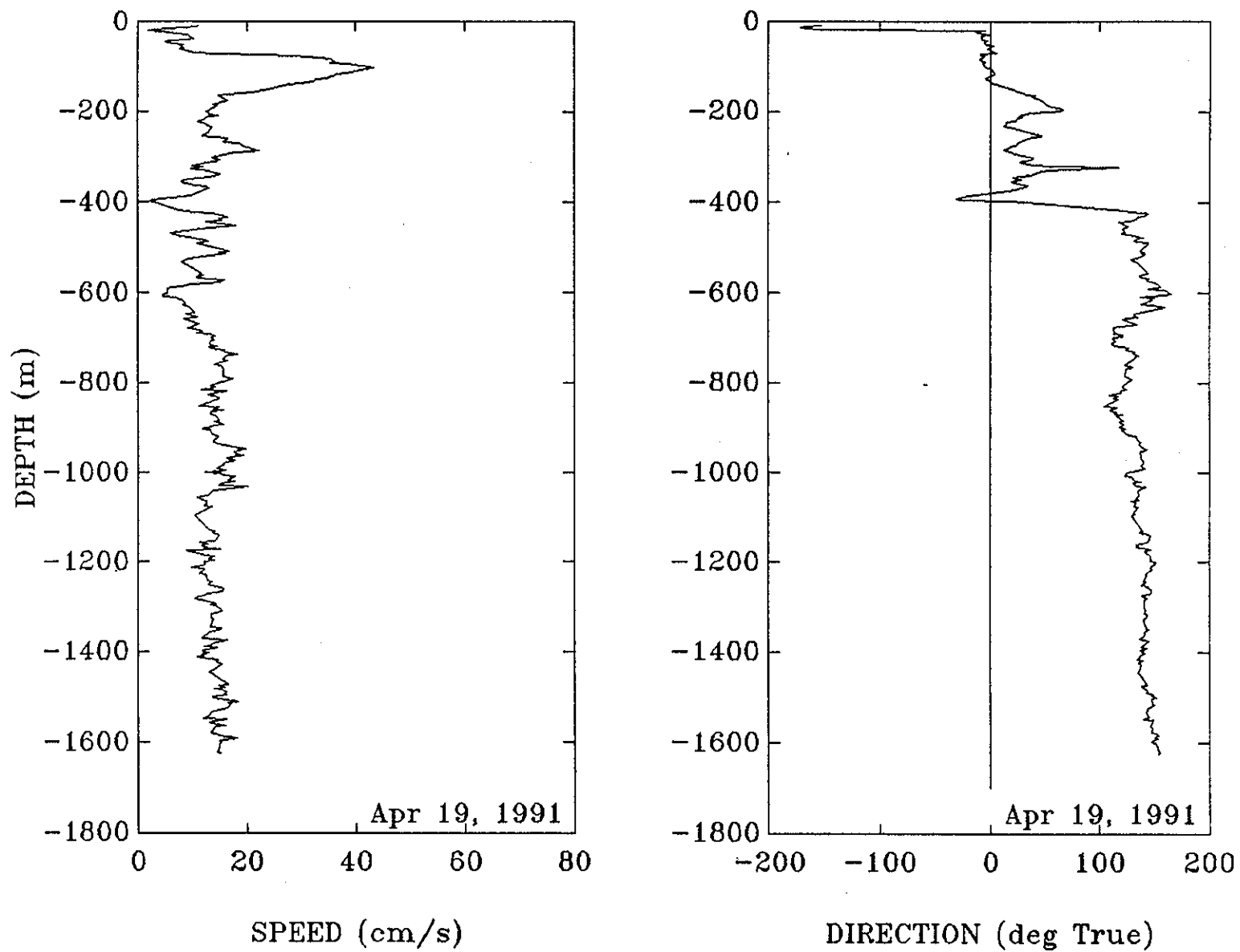


Figure A-9. XCP Profiles, Survey 40a  
(b) Speed/Direction Profile

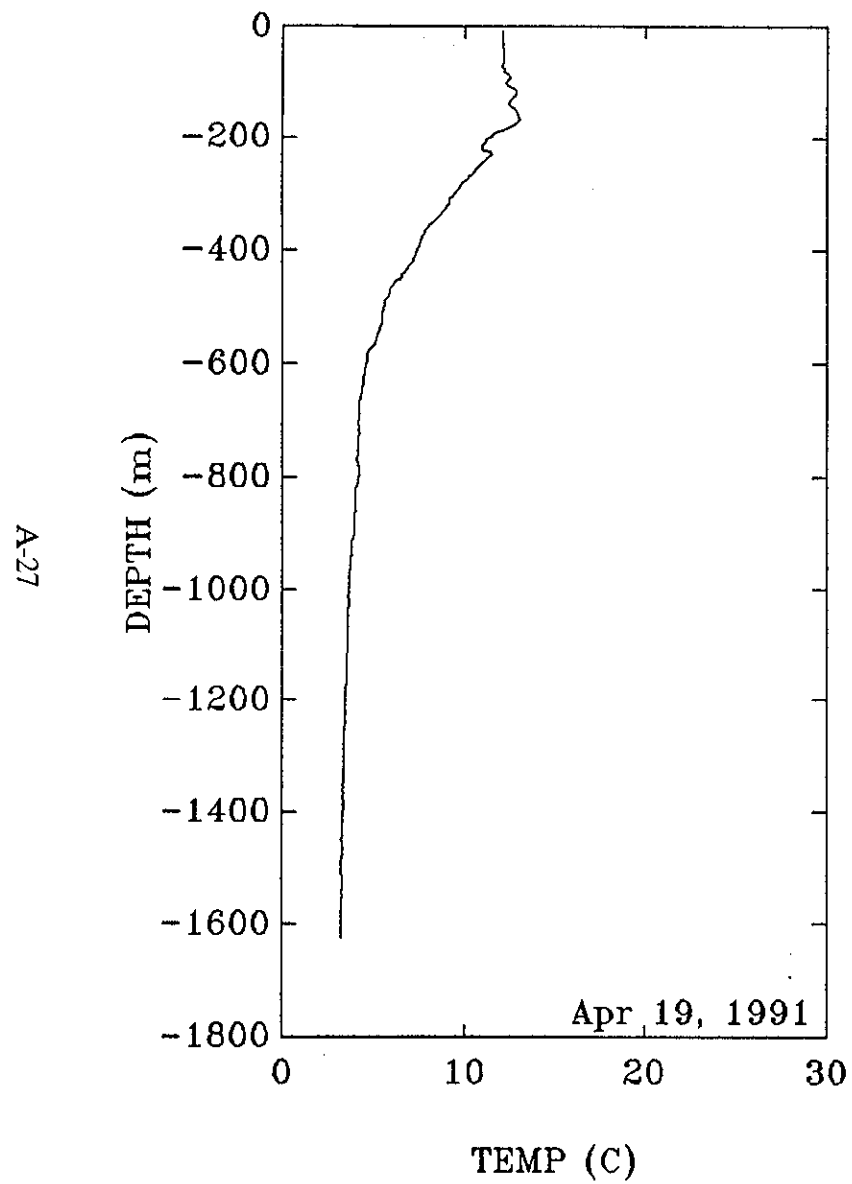


Figure A-9. XCP Profiles, Survey 40a  
(c) Temperature Profile

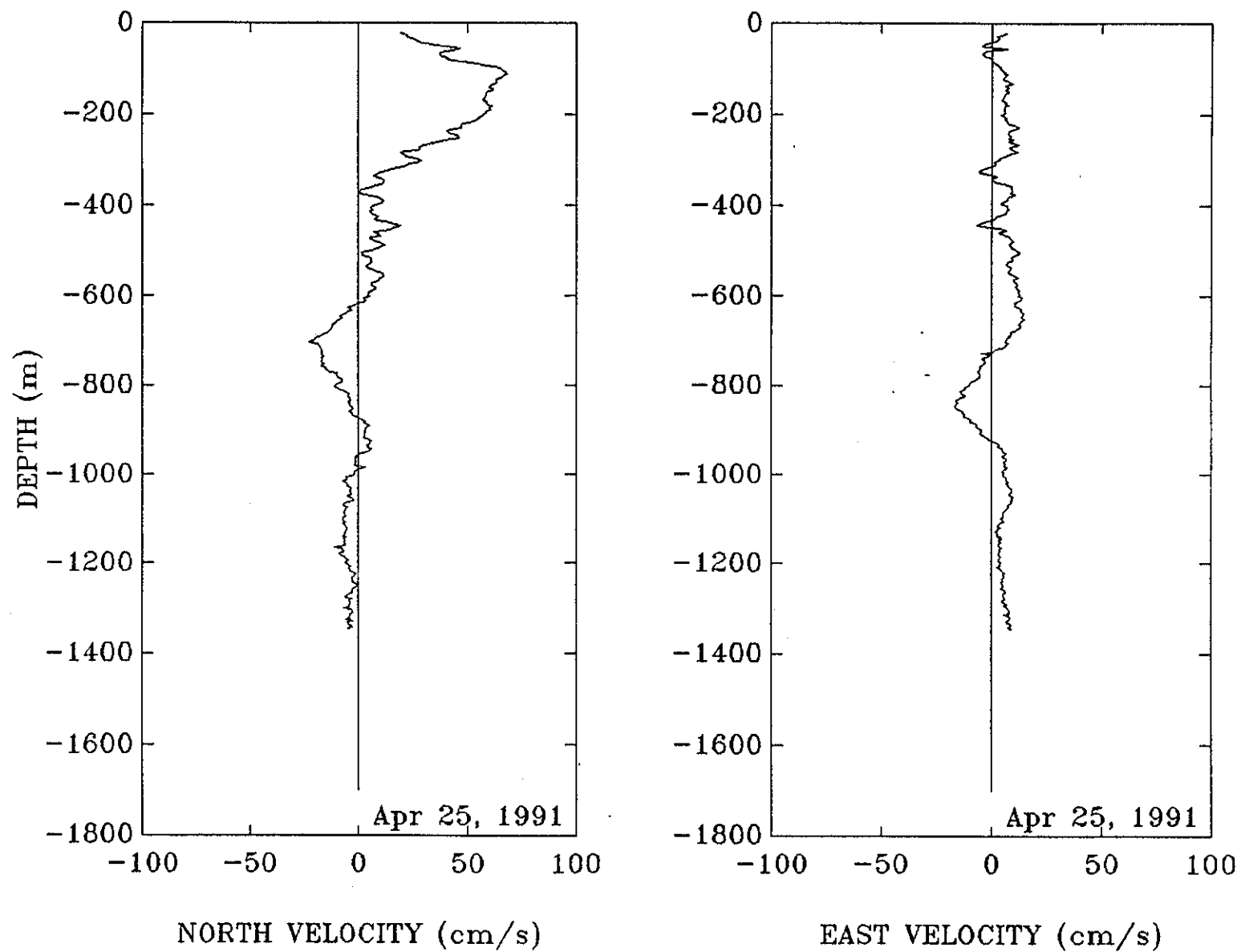


Figure A-10. XCP Profiles, Survey 41a  
(a) Velocity Components Profile

A-29

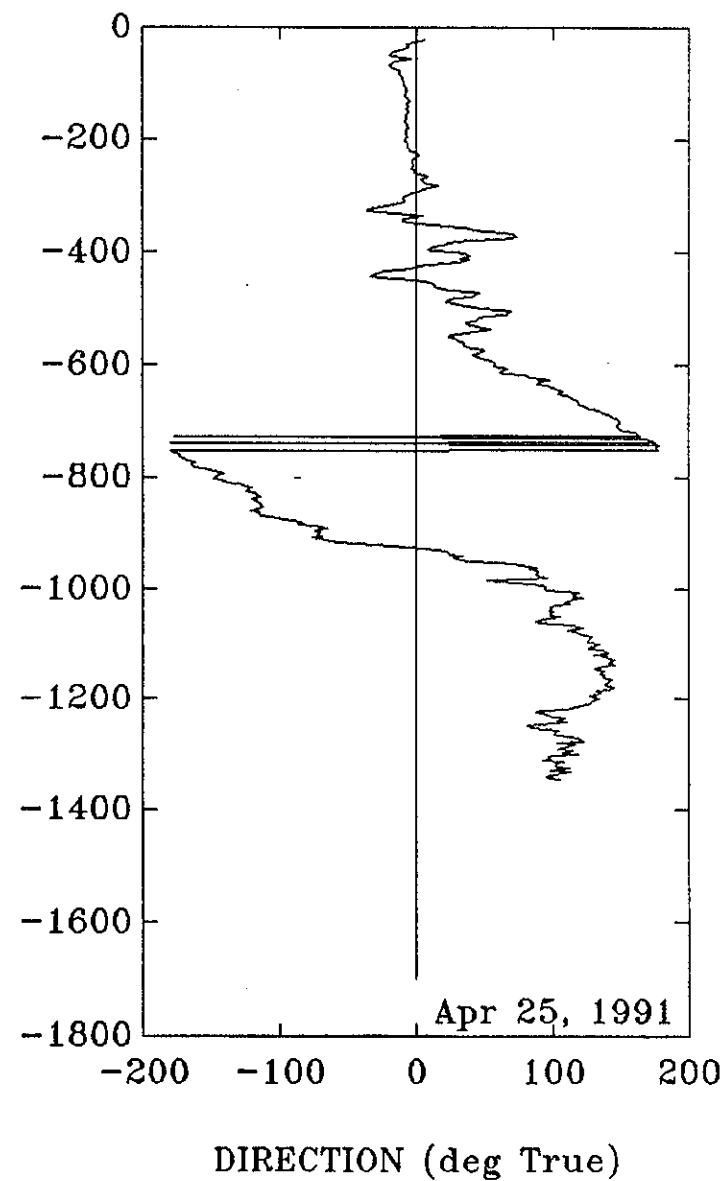
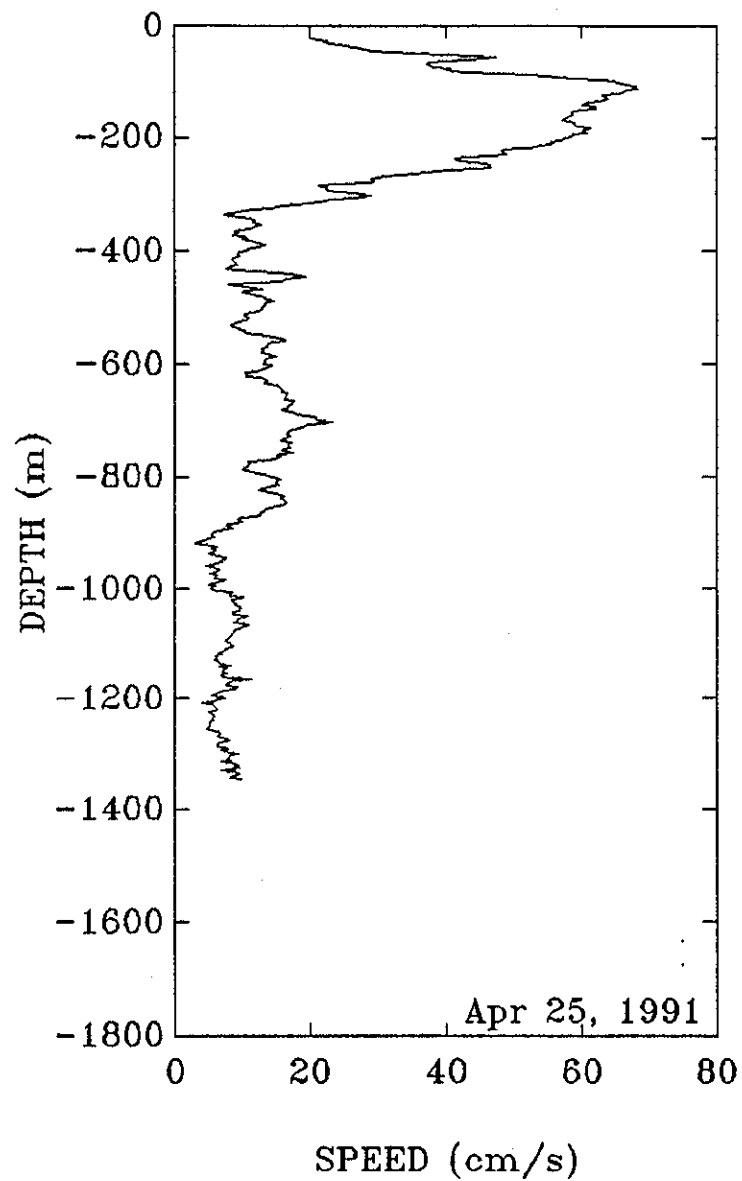


Figure A-10. XCP Profiles, Survey 41a  
(b) Speed/Direction Profile

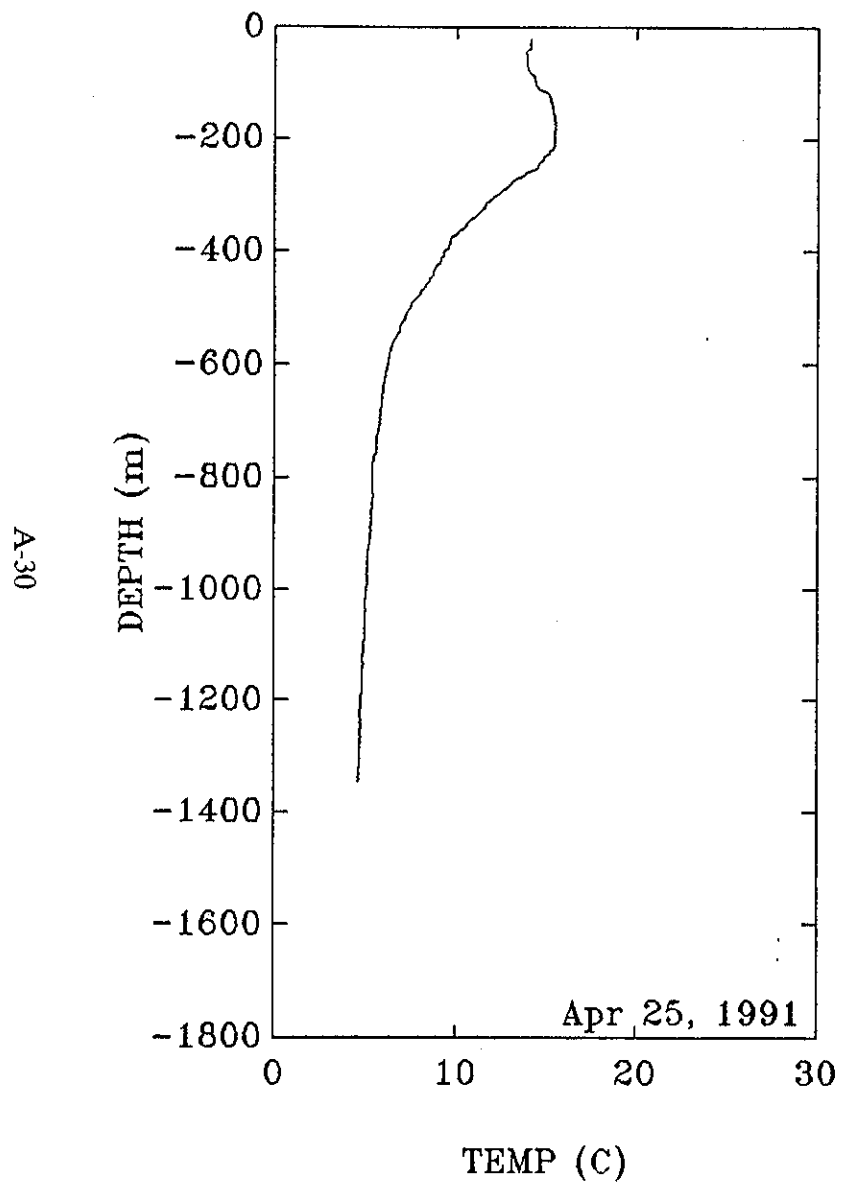


Figure A-10. XCP Profiles, Survey 41a  
(c) Temperature Profile

A-31

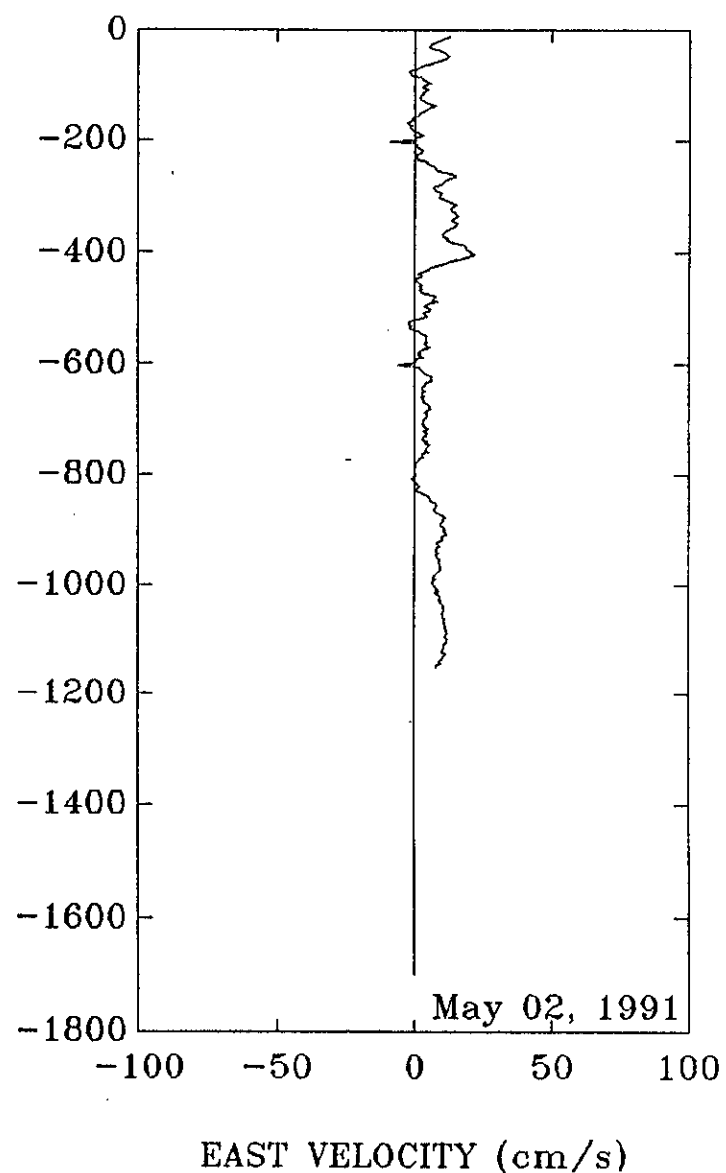
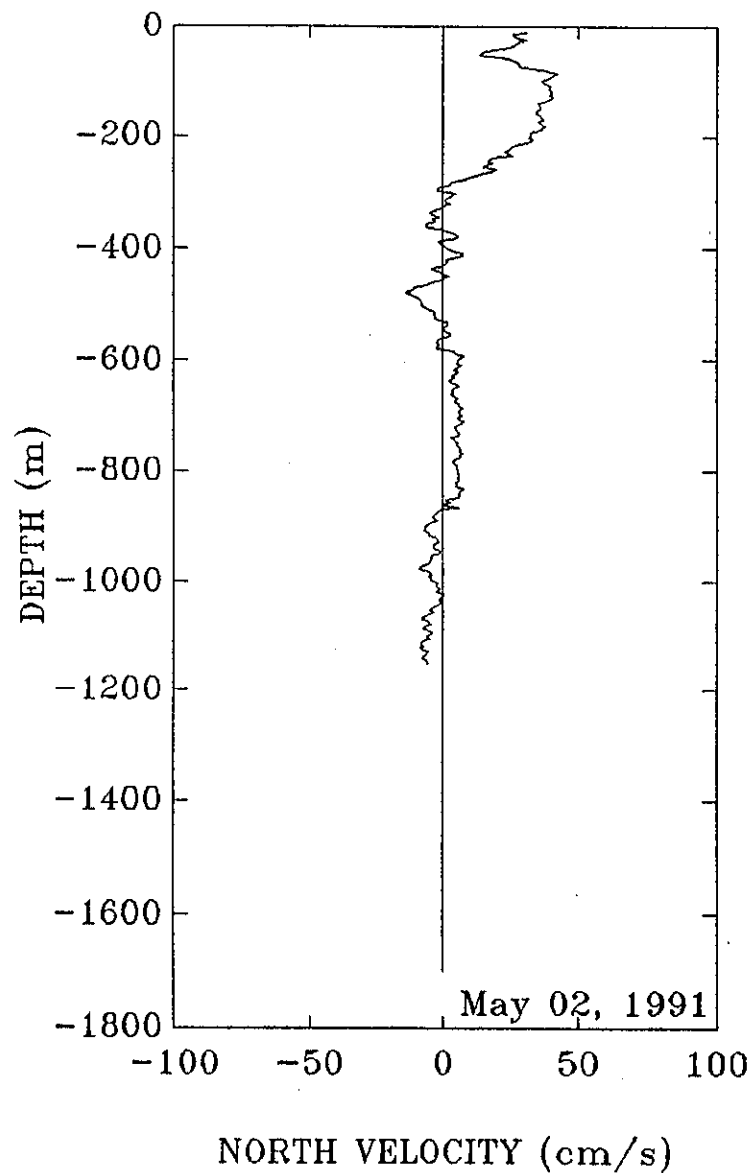


Figure A-11. XCP Profiles, Survey 42a  
(a) Velocity Components Profile

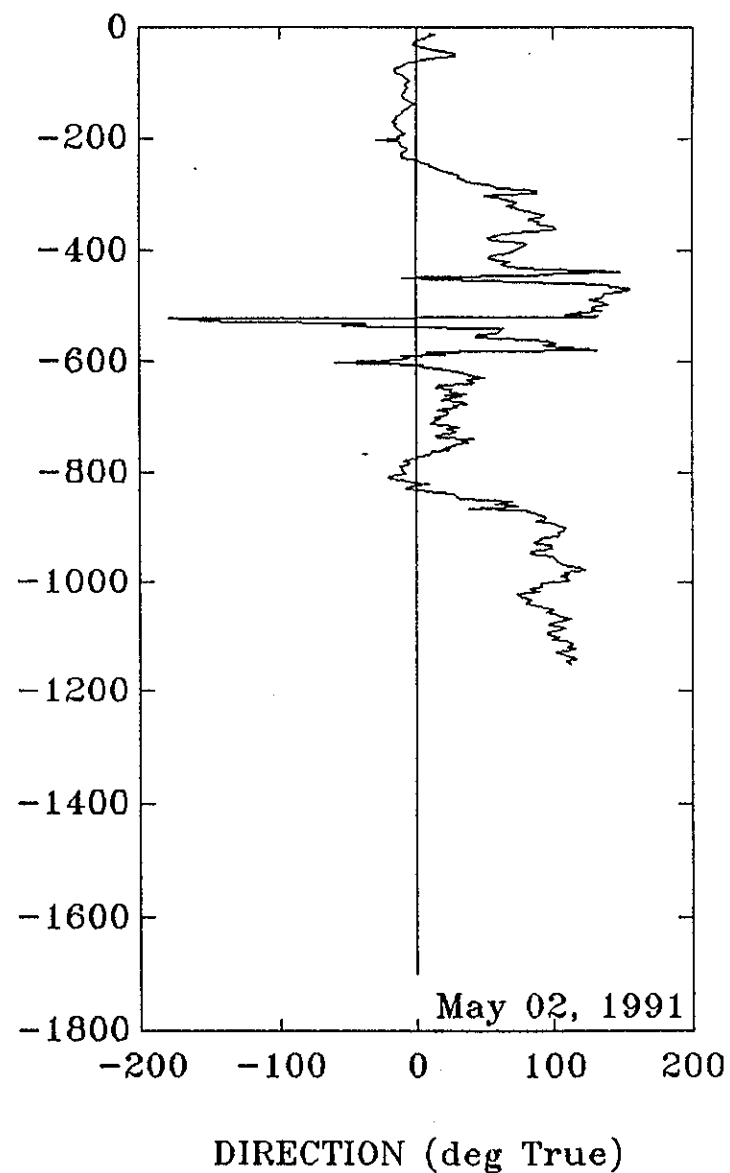
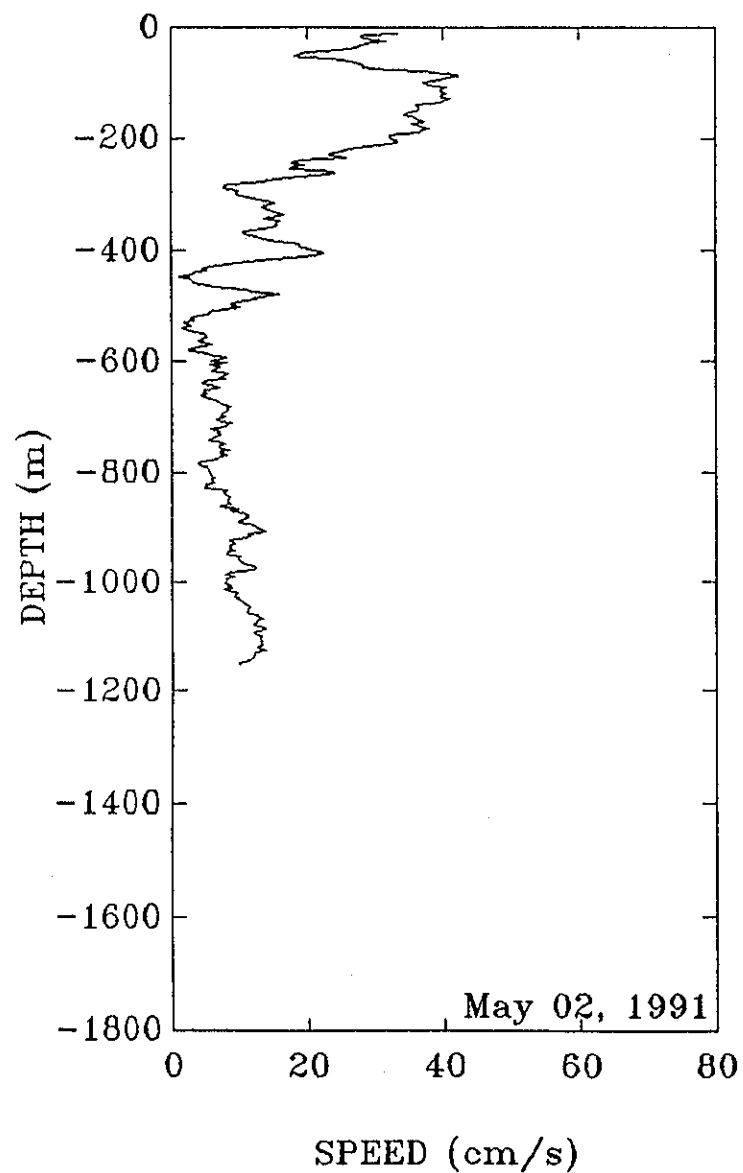


Figure A-11. XCP Profiles, Survey 42a  
(b) Speed/Direction Profile

A-33

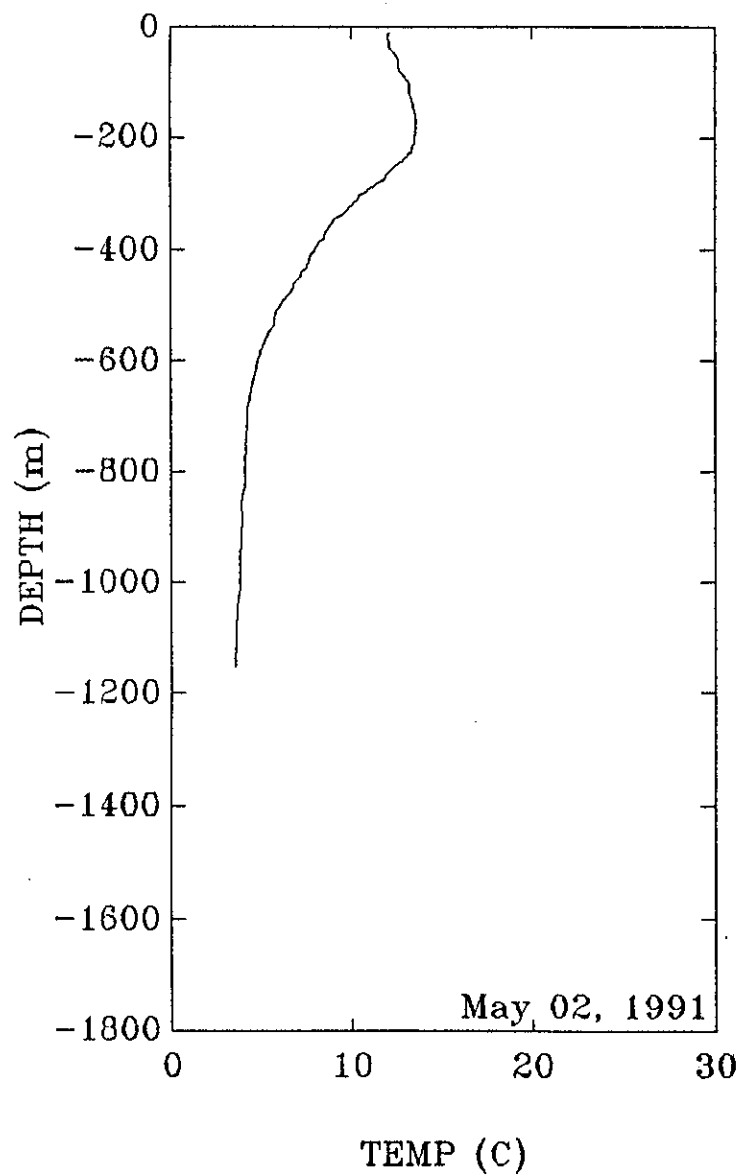


Figure A-11. XCP Profiles, Survey 42a  
(c) Temperature Profile

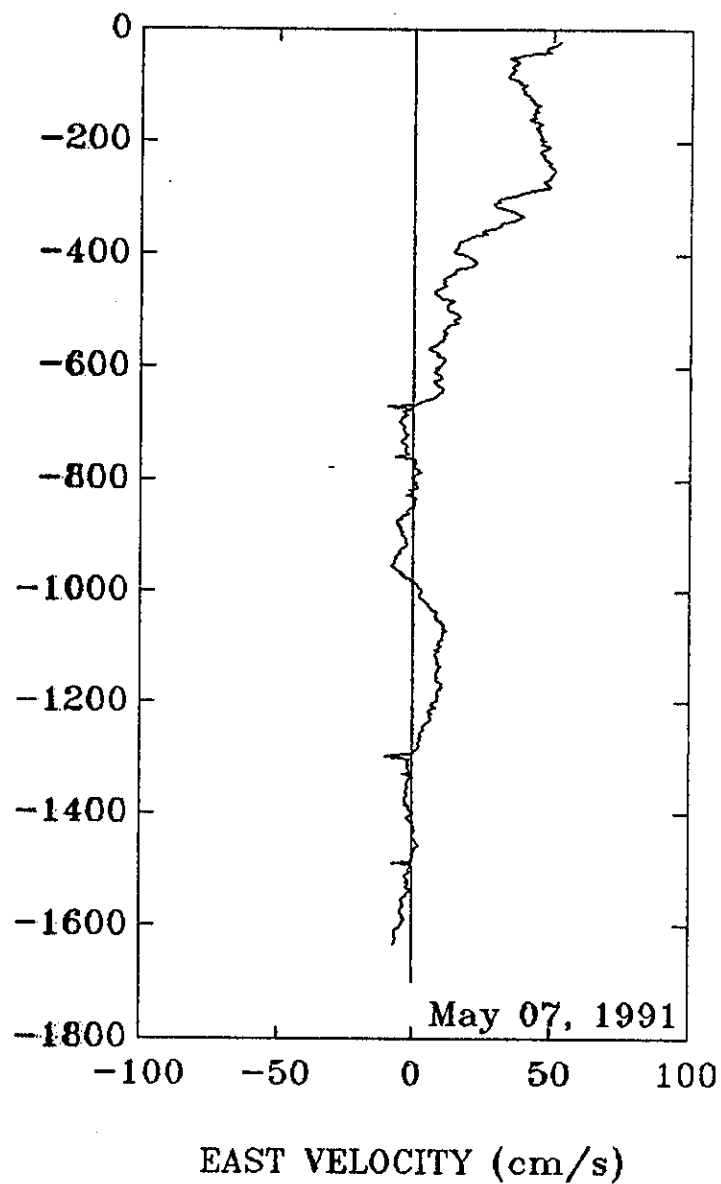
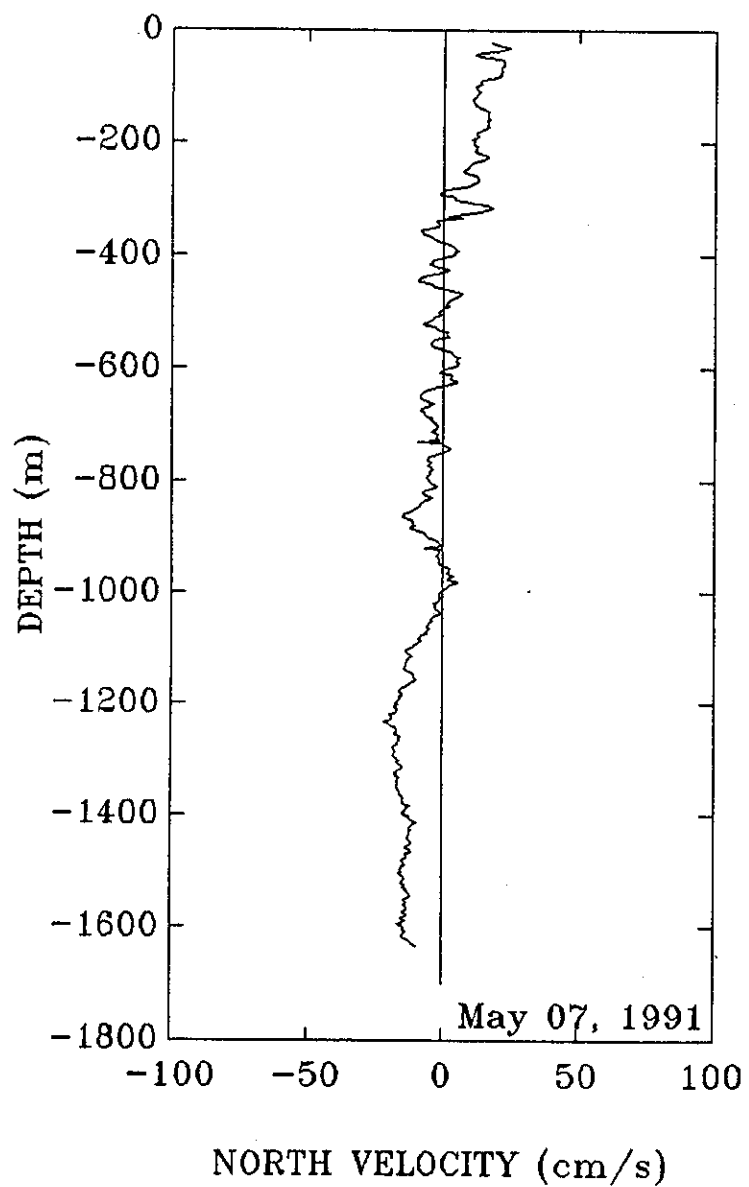


Figure A-12. XCP Profiles, Survey 43a  
(a) Velocity Components Profile

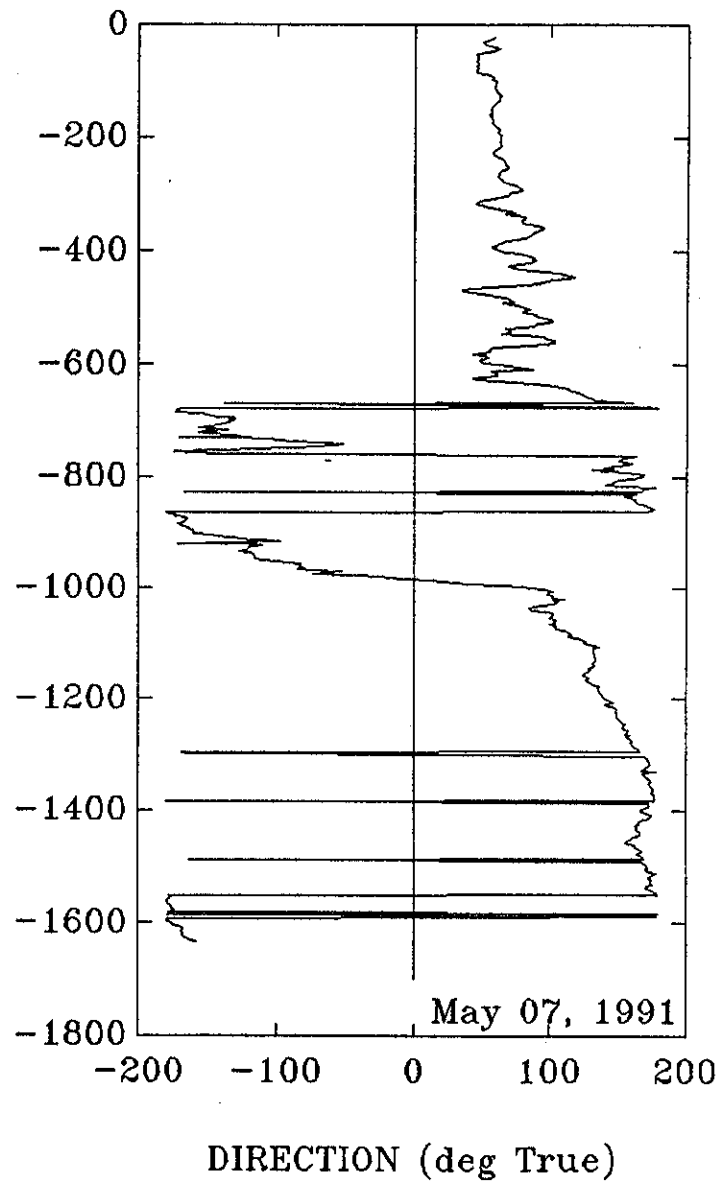
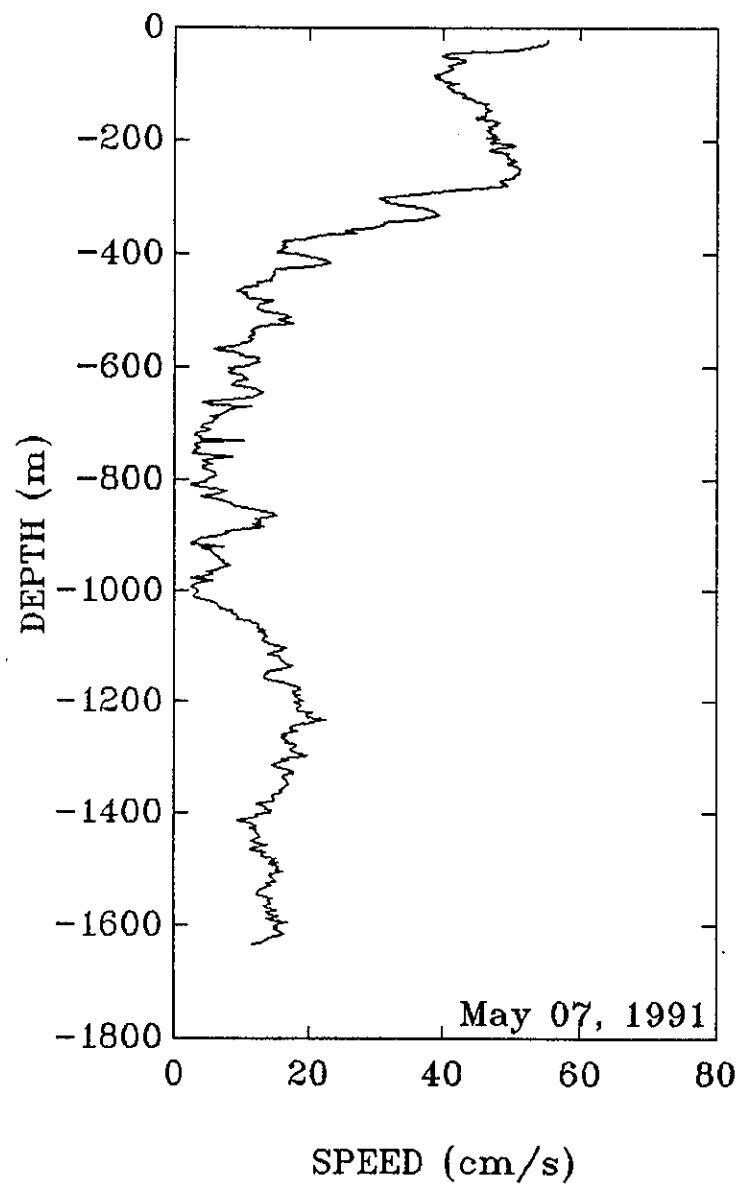


Figure A-12. XCP Profiles, Survey 43a  
(b) Speed/Direction Profile

A-36

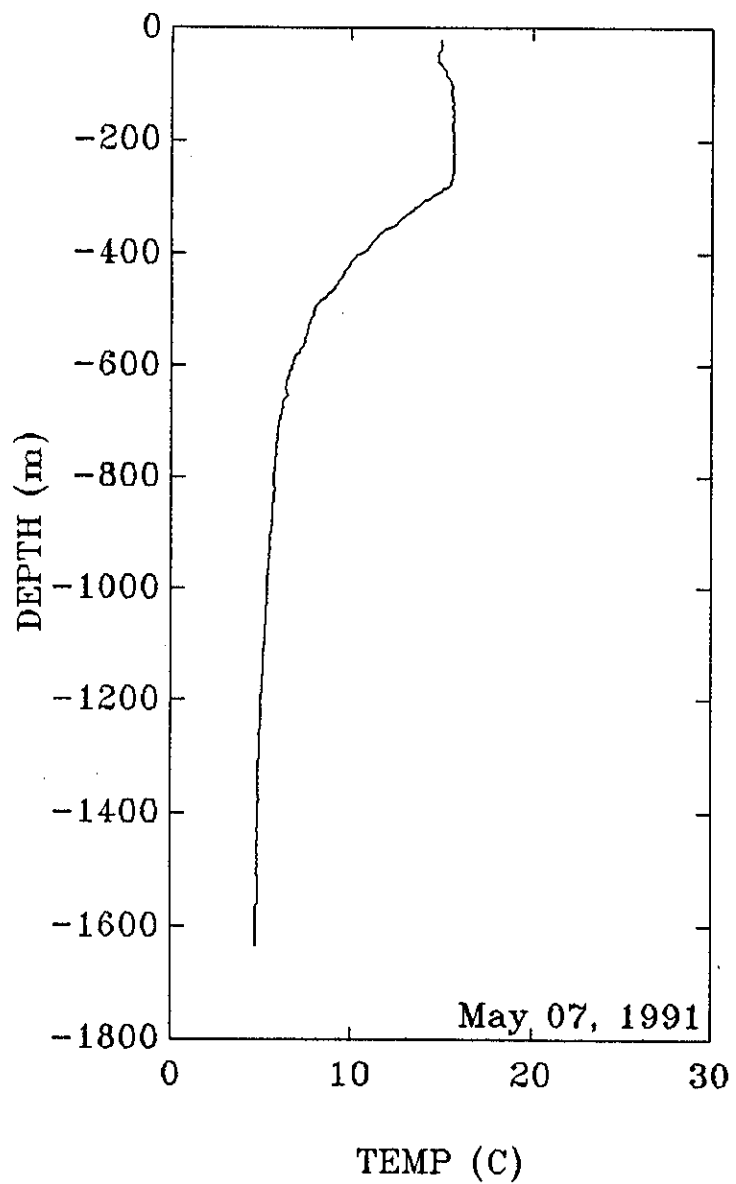


Figure A-12. XCP Profiles, Survey 43a  
(c) Temperature Profile

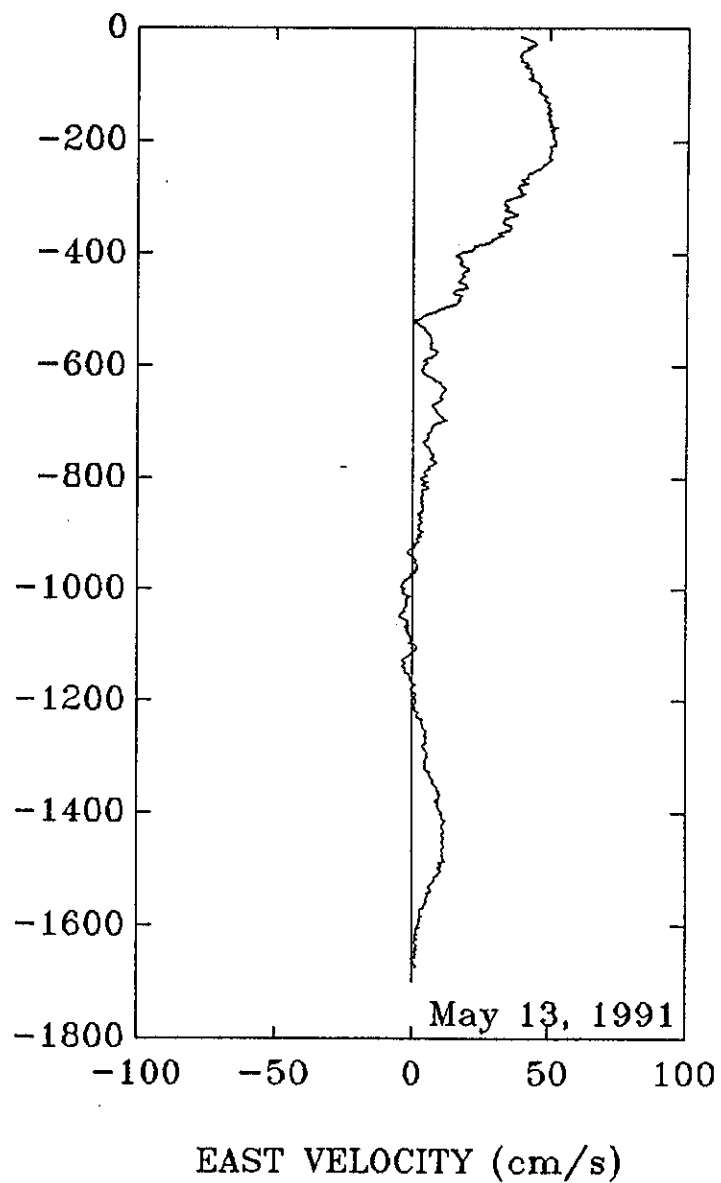
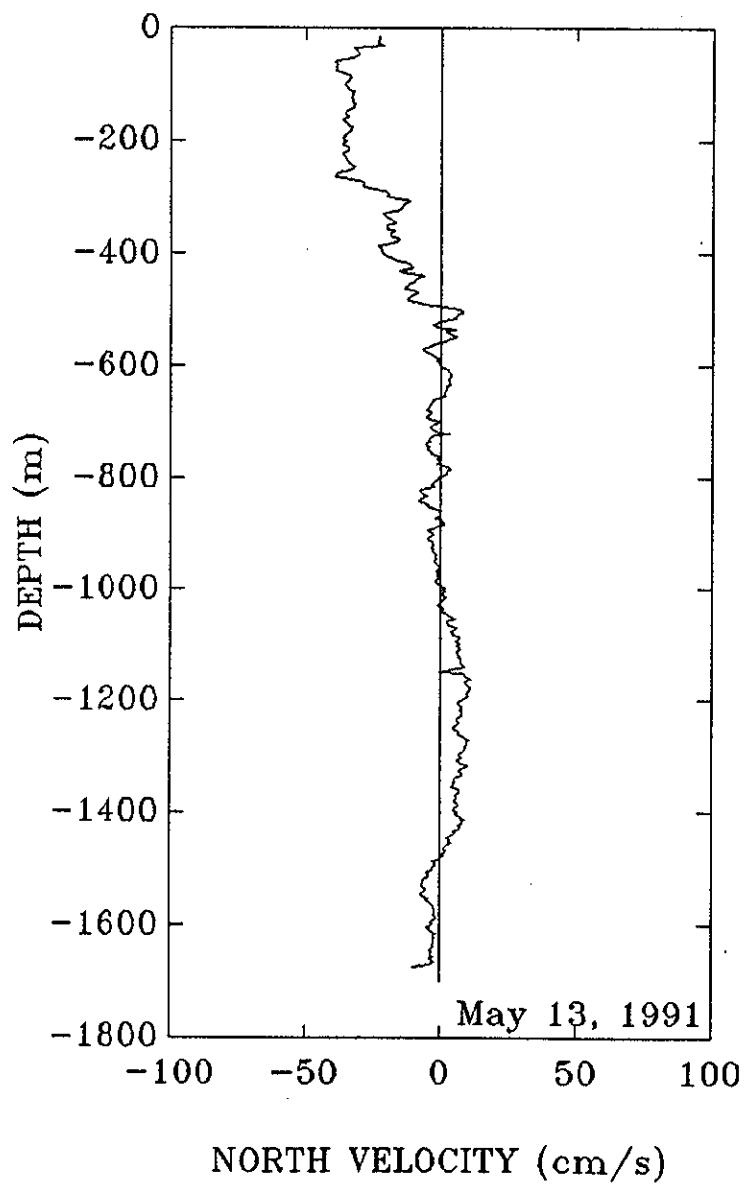


Figure A-13. XCP Profiles, Survey 44a  
(a) Velocity Components Profile

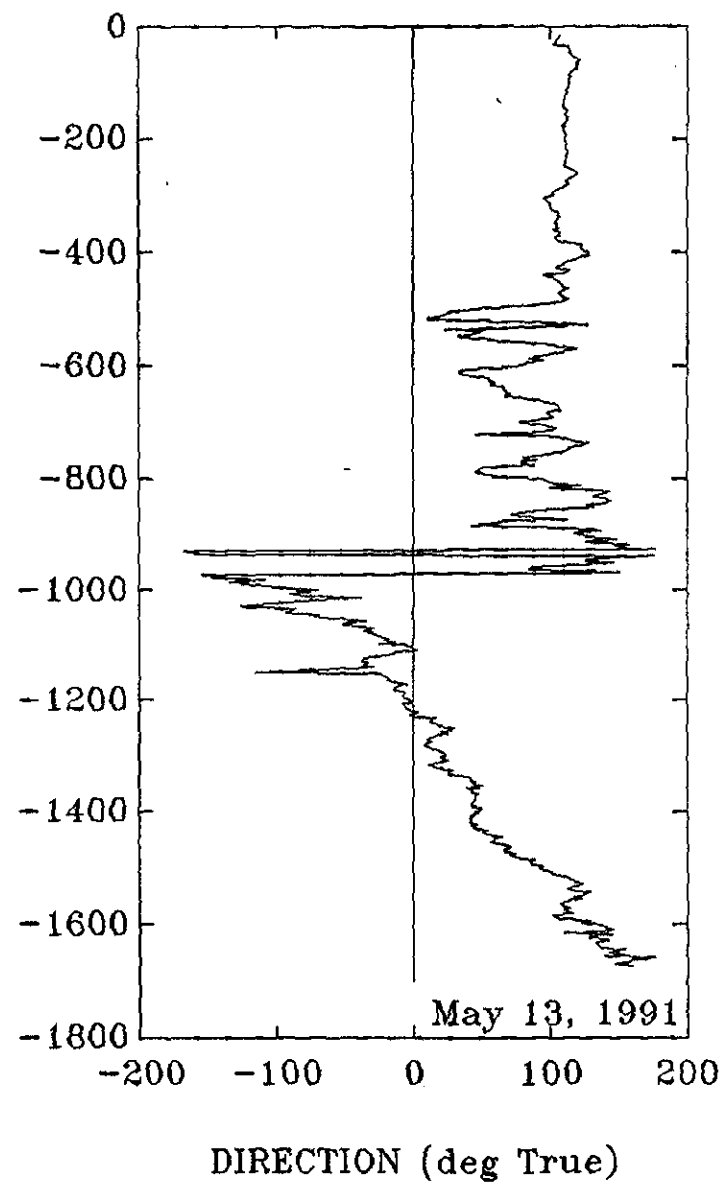
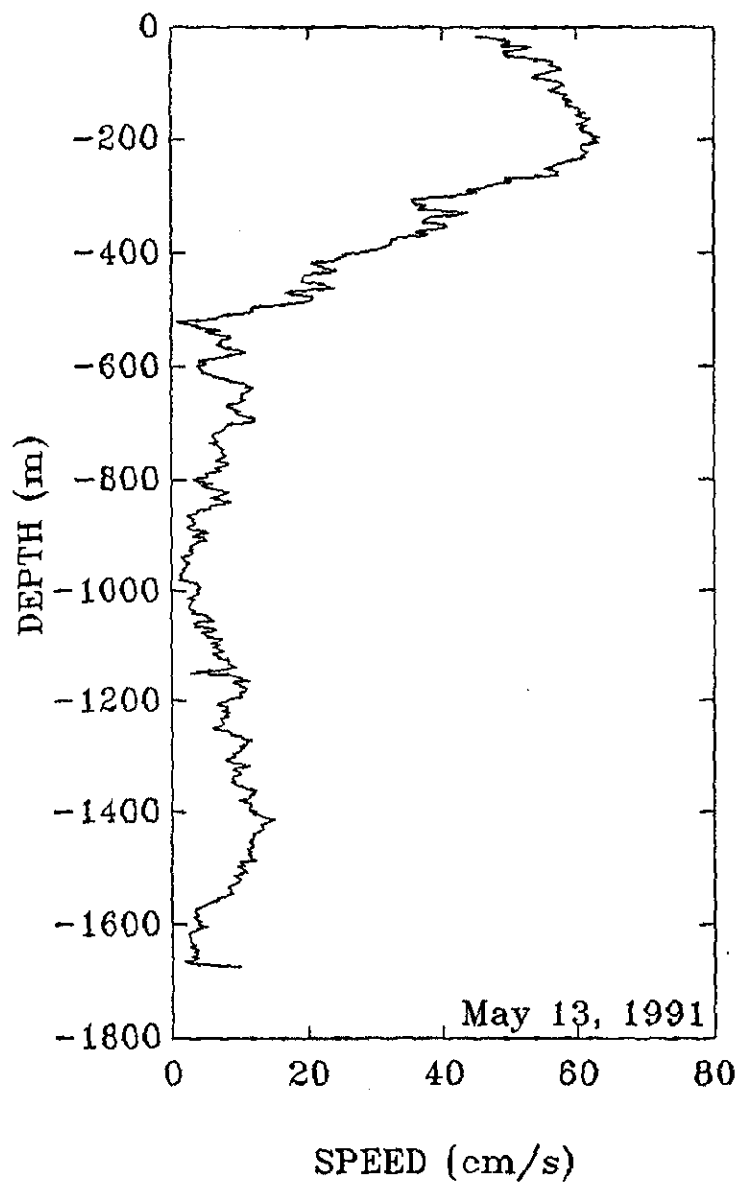


Figure A-13. XCP Profiles, Survey 44a  
(b) Speed/Direction Profile

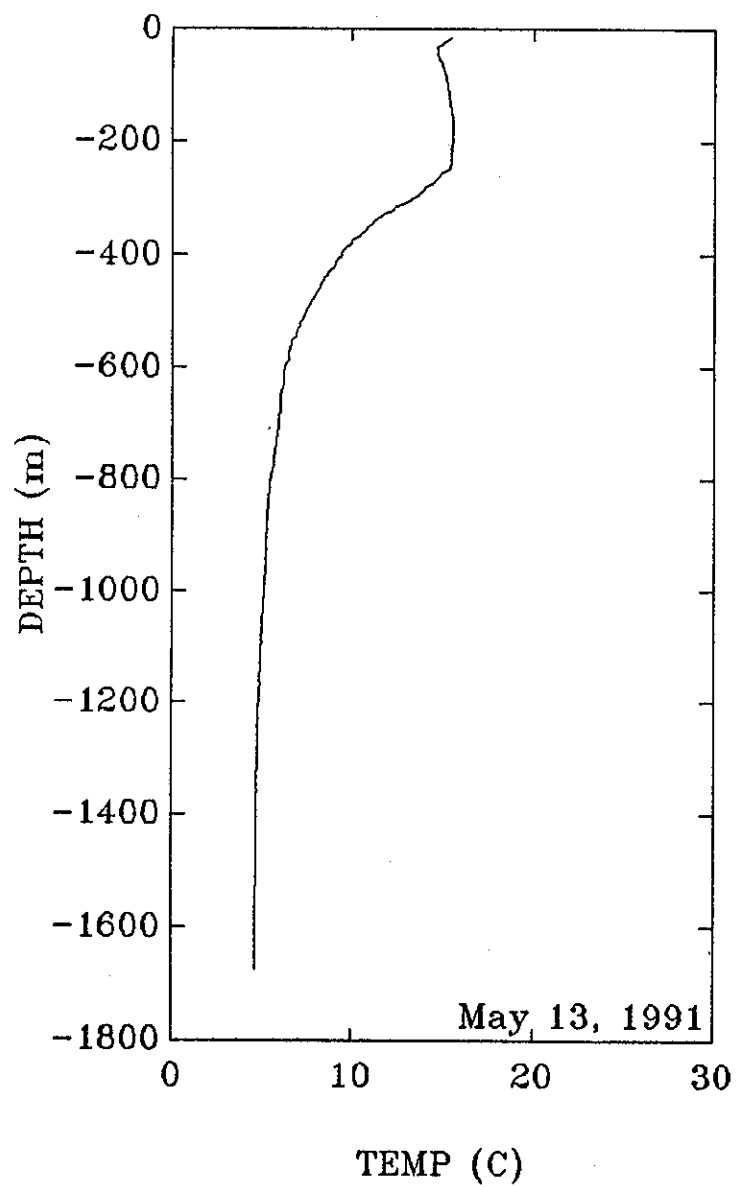


Figure A-13. XCP Profiles, Survey 44a  
(c) Temperature Profile

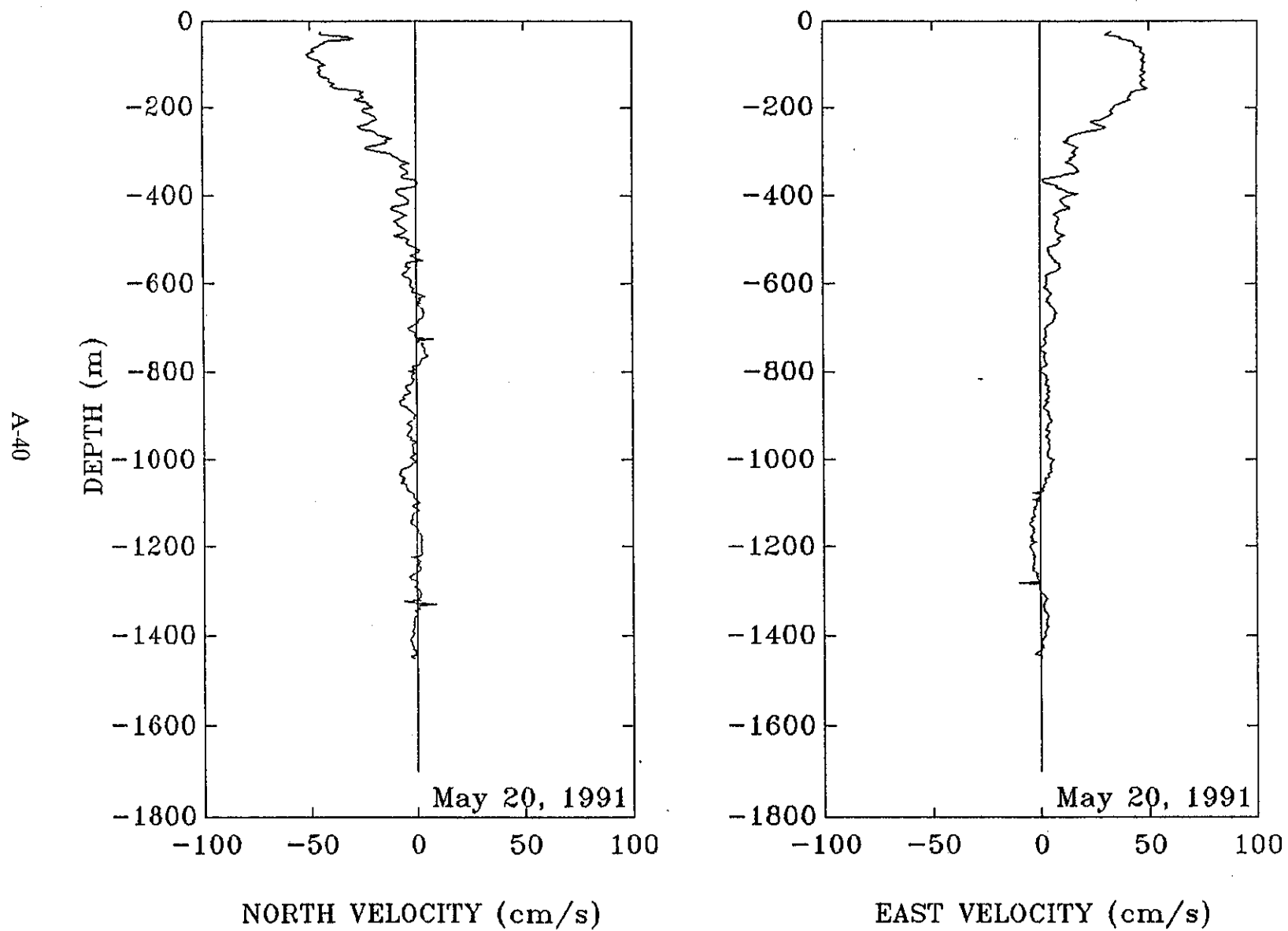


Figure A-14. XCP Profiles, Survey 46a  
(a) Velocity Components Profile

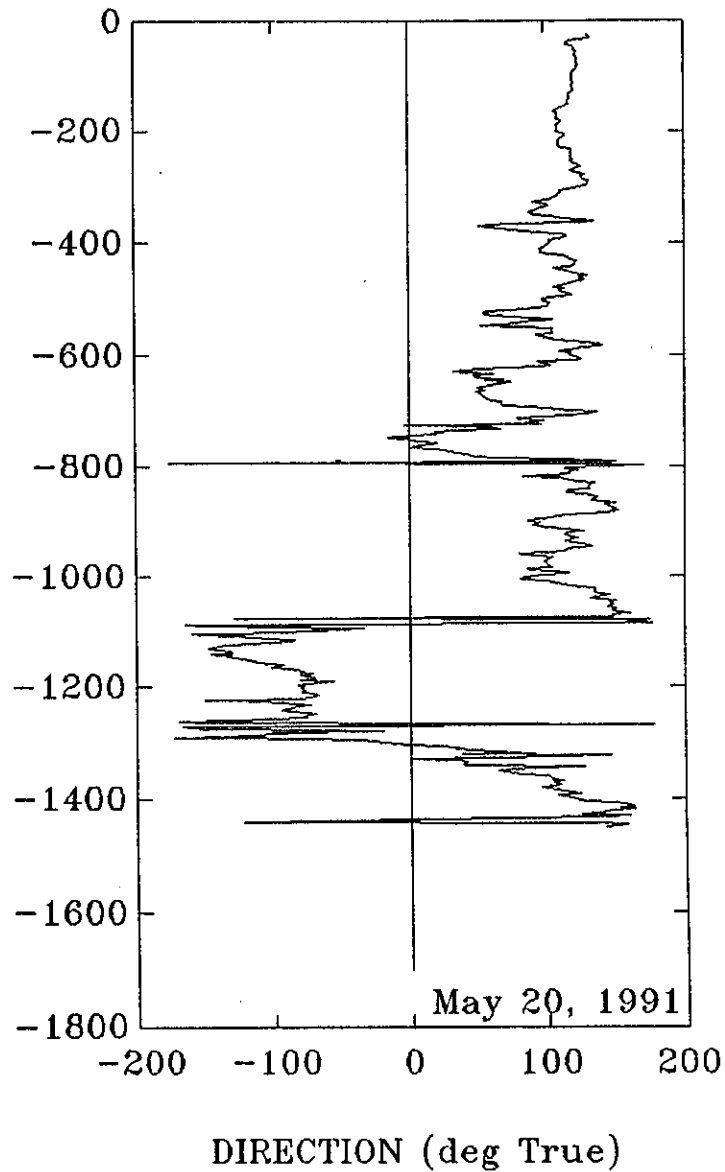
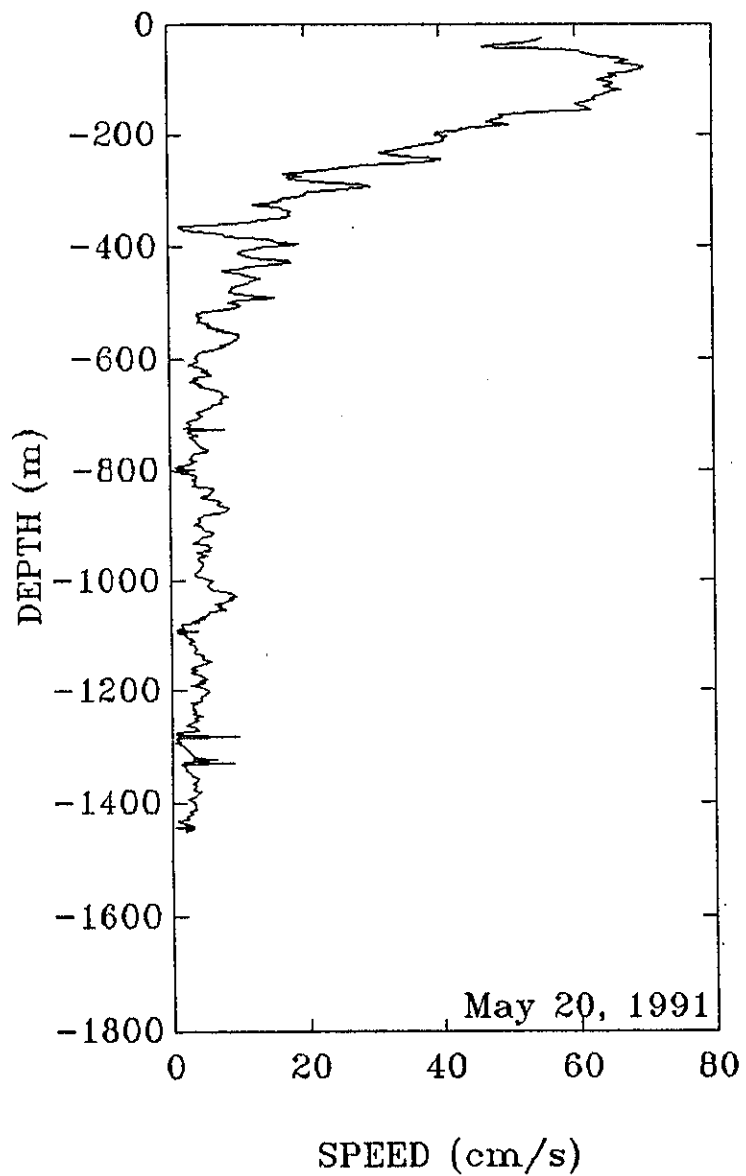


Figure A-14. XCP Profiles, Survey 46a  
(b) Speed/Direction Profile

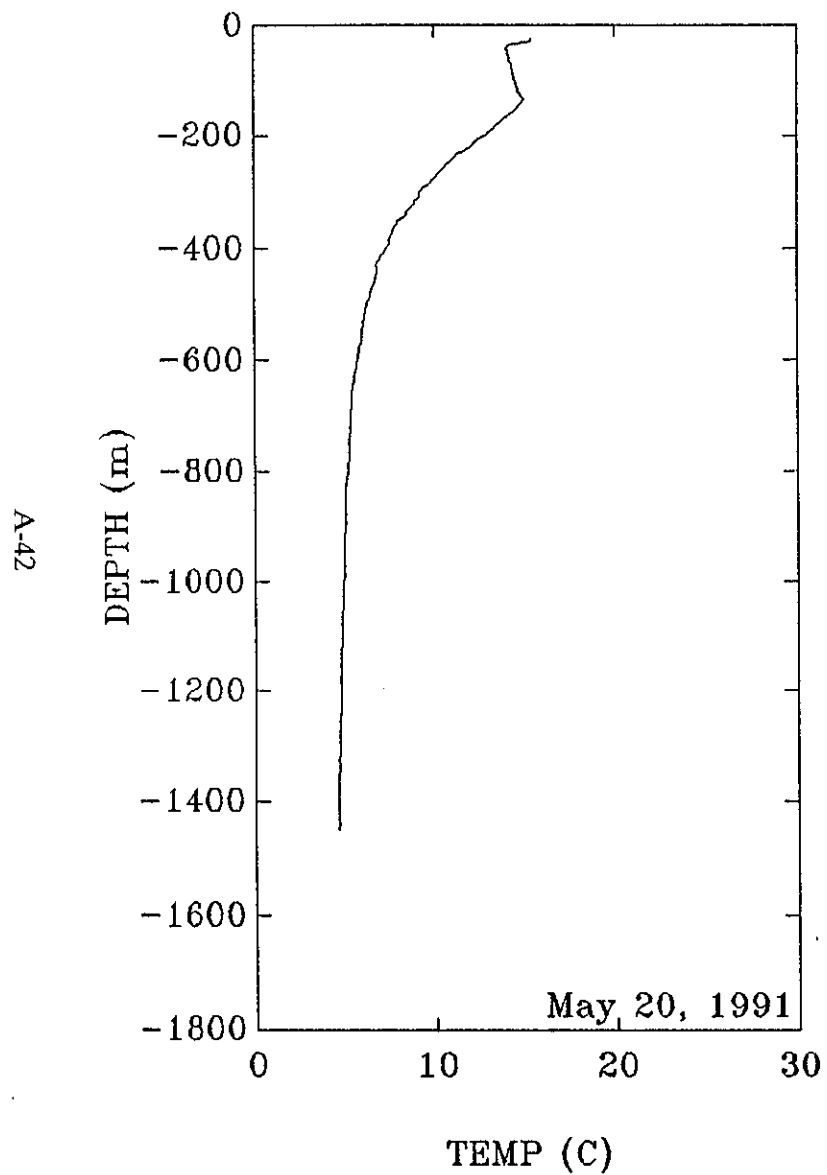


Figure A-14. XCP Profiles, Survey 46a  
(c) Temperature Profile